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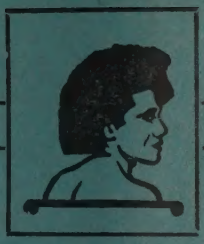

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OTHER PUBLICATIONS

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FORTHCOMING PUBLICATION

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Book ... ... The Fishes of Fiji, by H. W. Fowler (approximately 600 pages and 200 illustrations).

Agricultural Journal

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ISSUED BY THE DEPARTMENT OF AGRICULTURE, FIJI

Cocoa Seedlings in Nursery, Korovou

Photo—P.R.O.

Introduction

By J. M. WATSON, O.B.E., DIRECTOR OF AGRICULTURE

The devoting of a whole *Journal* to one crop is a new departure but it will serve to stress the importance with which the Department of Agriculture regards the development of a cocoa industry in this Colony.

Cocoa is no new introduction to Fiji and residents in Lami may have observed the few surviving trees of an old cocoa plantation which at one time existed there. It has been asked why these early plantations failed to survive; there are a number of causes for their gradual disappearance, not the least being the difficulty of transport and communications. Although it is confidently believed that many of the old-time obstacles to production no longer obtain, it would be presumptive to suggest that the answers to all the problems of cocoa cultivation are now known.

It was felt prudent, therefore, at this stage, to set forth all the Departmental knowledge and experience on cocoa production in the form of a series of articles constituting one issue of the *Journal* rather than produce an instructional Bulletin; this will follow later.

Work on cocoa in Fiji has been greatly stimulated by the interest and encouragement which it has received from Messrs. Cadbury Bros., Ltd. The excellent coloured plates in this issue were provided free by this firm. There are many other organizations too numerous to mention which have also rendered valuable assistance. Last, but by no means least, the Department owes a debt of gratitude to the many " pioneers " who have staked much on following the Department's guidance and are laying a valuable foundation for the future.

This Introduction would not be complete without reference to the basic spadework done by Mr. L. W. Harwood, who will shortly be retiring from the Government service. I feel sure that his name will long be associated with the establishment of cocoa in Fiji.

THE ESTABLISHMENT OF A COCOA INDUSTRY IN FIJI

BY L. W. HARWOOD

Although planned development of a cocoa industry began in 1953, many attempts to establish the crop were made after Cession in 1874. Early settlers, especially those in remote and isolated parts of the group, felt that cocoa might be a crop which would overcome their storage and transport problems and provide a reliable source of income.

The first introductions of cocoa were made about 1880 by Mr. J. B. Thurston, later Sir John Thurston and Governor of Fiji. Further introductions of pods from India, Singapore, Java and Western Samoa were made by the Department of Agriculture between 1905 and 1909 and approximately 200 acres of cocoa were planted on the islands of Viti Levu, Vanua Levu and Taveuni during this period. The disastrous hurricane of 1912 is blamed for the abandonment of the industry although poor communications and low prices were presumably contributory factors.

There was a revival of interest in Cocoa during World War II. A preliminary survey of surviving trees on Vanua Levu and Taveuni was made in 1943 (ffrench-Mullen) and proved of particular value when plans for the industry were being made. Shephard (1944) and Patterson and Dodds (1945) considered that the industry should be revived as cocoa would prove a valuable alternative crop for outlying districts which were—and are—virtually dependent on bananas.

The necessary impetus for the re-establishment of the industry was provided by the visit of Urquhart (1952). Following his encouraging report, a special committee recommended that cocoa be developed as a matter of urgency. Subsequent development was materially assisted by the introduction of selected clonal material from Trinidad, Papua-New Guinea and Western Samoa. These introductions and local seedlings were established at the Plant Introduction and Quarantine Station, Naduruloulou, from 1948 onwards.

A survey of surviving cocoa trees was commenced in 1954. Even before this was completed over six thousand trees had been located, pruned, rehabilitated and labelled with a distinguishing number. Pods from the trees found in the survey and those at Naduruloulou have been regularly collected for classification and propagation since the inception of the survey. Careful records of yields showed that a good nucleus of high-yielding trees was available and the performance and quality of the local clones compared very favourably with those of the best introductions.

The completion of the aerial and reconnaissance soil surveys of Viti Levu, which were followed by more detailed surveys of Viti Levu, Vanua Levu, and Taveuni and, later, of the remainder of the Group, confirmed Urquhart's opinion that large tracts of potential cocoa land existed in Fiji. The preparation of soil maps from the surveys carried out by Fox, Baumgart, Wright and Twyford has materially assisted planned development.

Up to the present, development has been restricted to the provinces of Naitasiri, Tailevu, Cakaudrove and selected areas in Ra and Nadroga-Navosa; however, with increasing seed supplies, extension to Koro, Ovalau, Wainunu and Kadavu is planned during the coming planting season.

All cocoa farmers are registered. Registration, which is purely voluntary, provides some control over the industry in that registered farmers are provided with selected seedlings of the desired type while farmers in unsuitable areas may be dissuaded from planting. This system facilitates the development of economic areas and effective supervision of planting and processing, especially where the co-operative fermentation and drying of cocoa beans is envisaged. A system of registration is of special value in the event of the crop being attacked by

Plate 1. Seedling Cocoa, 3 years old under thinned forest, Burerua

Photo—R. Burness

some serious pest or disease in that the whereabouts of all commercial plantings are known.

Intending planters should apply to the nearest Agricultural Extension Officer who will advise them on the selection, preparation and, later, the planting of their land. Six hundred seedlings are issued free of charge to any farmer whose application is approved and whose land has been prepared to the satisfaction of the local Extension Officer. The seedlings are supplied from nurseries established throughout the cocoa areas; additional seedlings may be supplied at £3 per hundred whilst a limited number of rooted cuttings can be made available at £15 per hundred. Planting material of shade trees, when required, is provided free of charge.

By the end of 1958, sufficient seedlings to establish 1,843 acres of cocoa had been issued to farmers of all races. As anticipated by Urquhart, *loc. cit.*, the Fijian people have shown keen interest in this new crop and are responsible for most of the plantings. In order to facilitate the collection and procession of cocoa, especially where co-operative effort is concerned, no plantings are encouraged unless a minimum of ten acres—and preferably thirty acres—can be established in a district. As a result there are now 48 areas in which a minimum of ten acres has been planted. In addition, a local company with large plantation interests has interplanted 246 acres of coconuts with seedling cocoa, the planting material for this venture being provided by pods of local selections and selected seed from Papua-New Guinea and Western Samoa introduced under permit.

Various methods of establishment have been tried. The Fijian does not take kindly to the traditional West Indian method of clearing and establishment of permanent and ground shade before planting the cocoa, and therefore interplanting of thinned bush or established coconuts would seem to be the best methods for Fijian planters. Planting " at stake " has been tried by a local company but was abandoned because of insect damage in the early seedling stage and the cost of regular spraying and replacements.

Standards of preparation, planting, and maintenance have been very variable. Recent surveys show the need for considerable rehabilitation and consolidation of existing plantings, but there is definite evidence that the farming community is beginning to appreciate the requirements of the crop. Once the farmer realizes that cocoa must have overhead shade, especially in its young stages, and that best results are achieved by careful manipulation of the shade as the tree grows, the standards of planting and maintenance will improve appreciably.

The successful introduction and establishment of Dadap (*Erythrina lithosperma*) from Western Samoa has made a quick-growing, permanent shade tree available in rapidly increasing quantities. Supplies of planting material do not yet meet the demand, but with the development of Cocoa Stations this state of affairs will soon be remedied.

The Plant Introduction and Quarantine Station is being rapidly developed as a Cocoa Station, where the main emphasis will be on vegetative propagation of local and introduced clones and also fermentation and drying experiments. A similar Station, which will allow of more agronomic work, is being established in the Nasavusavu district of Vanua Levu with the aid of funds provided from a Commonwealth Development and Welfare Grant. The development of these Stations, both of which are situated in areas where large scale development is possible, should give a tremendous fillip to planting.

Mention has been made of the work done in selecting local clones and the establishment of clonal nurseries at Naduruloulou. By arrangement with Messrs. Cadbury Bros. Ltd., pods of promising trees have been fermented by the Wadsworth-Howat method and the cured beans sent to them for appraisal of quality. The reports received have greatly facilitated selection. In addition, the necessary equipment for the laboratory manufacture of chocolate has been acquired and will be installed at Naduruloulou. A local tasting panel has been established.

Plate 2. Seedling Cocoa under thinned forest, Bureua

Photo—P.R.O.

The prospects of marketing Fiji cocoa have been investigated. Laboratory-prepared samples of cocoa beans have been sent to buyers in the United Kingdom, the United States of America, Canada, Australia and New Zealand for assessments of quality and an indication of their market potential. Reports received to date suggest that the flavour of Fiji cocoa is predominantly mild and, whilst our beans should meet with a ready sale, some manufacturers would prefer a stronger chocolate flavour. In order to ensure the production of beans which will satisfy the majority of the buyers, a breeding programme designed to produce cocoa of stronger flavour is in hand. In addition, seed of West African Amelonado, which is esteemed for its strength of flavour, has been successfully introduced from Malaya.

An important stage has now been reached. Cocoa planted in 1953 and 1954 is coming into bearing. An experimental fermentary and Samoan-type drier have been constructed and put into operation at Naduruloulou; similar units will be constructed in Vanua Levu and Taveuni during 1959. These fermentaries, which are cheap to construct and efficient in design, should enable the Department of Agriculture to carry out the necessary investigational work on a field scale, to train subordinate staff and fermentary attendants and to handle the processing and drying of cocoa until such time as a satisfactory scheme of marketing smallholders' cocoa has been evolved. A programme of fertilizer investigations has been commenced; the information obtained from these experiments should enable the Department to make specific recommendations for the various soil types on which cocoa is grown.

The foundation for a large industry has been successfully established. Results to date show that conditions in Fiji are suitable to the crop. The next and very real problem is to see that cocoa of a quality suitable to the trade is produced for export and that proper export standards are adhered to.

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NOTES ON THE BOTANY OF COCOA

BY C. WALKER

All varieties of cocoa are trees of the lowest storey of lowland tropical forests. The bulk of the world's cocoa is grown within 10° North and South of the equator and below 1,000 ft. in elevation, with the limits of cultivation at about 20° North and South.

HABIT OF GROWTH

The various kinds of cocoa differ little in general habit and may reach a height of 30 ft. (average 15–20 ft.). The seedling forms a straight main stem which, at about 3–5 ft. high, forks into 3, 4 or 5 main branches forming what is known as the fan or jorquette. The terminal bud, or growing point, is used up in the formation of this jorquette and any further increase in height is made by a sucker, or chupon, which arises later, usually just below the jorquette; the chupon grows vertically between the branches of the first jorquette and, a few feet higher up, forms a second jorquette, thus giving the tree a second storey.

Third and fourth storeys may be formed by further jorquette growth. Because of hurricanes, and in order to facilitate harvesting, cocoa planters in Fiji are advised to confine their trees to a single lower storey by systematic pruning.

BRANCHES

The cocoa tree exhibits dimorphic branching, i.e. it develops two types of branches:—

(1) The Upright or Chupon type; this includes the first main stem of the seedling and bears its leaves in a $\frac{3}{8}$ spiral; its growth is determinate, as sooner or later it will give rise to a fan-type branch.

(2) The fan-type branch bears its leaves alternately and in one plane; its growth is indeterminate and gives rise normally to laterals of its own kind.

Generally, a chupon will give rise to a chupon, except at the jorquette, and a fan will give rise to a fan. But while it is very rare for a chupon below the jorquette to give rise to a fan-type branch it is not uncommon for a fan to give rise to a chupon; this is a desirable feature in vegetatively propagated cuttings planted out in the field, as it does permit the growing of a normally shaped tree.

LEAVES

The leaves are produced in delicate flushes and they hang vertically; as they become older they firm and normally become dark green in colour but remain relatively thin. Generally, the leaves are dropped from the third flush back from the terminal bud but this depends on the environment and nutrition; the poorer the environment and availability of nutrients, the fewer the flushes retained.

There is no correlation between the colour of a flush and the cotyledon colour of the beans of a tree but the external colour of the pod may be indicated by the flush colour. Very light green or creamy flushes will indicate a green pod while dark red flushes will indicate a red pod; but between these two extremes the correlation between flush colour and external pod colour breaks down somewhat.

FLOWERS

The cocoa tree is cauliflorous, i.e. the flowers are produced on the older leafless parts of the stem and branches. The flowers develop from cushions; these are really auxiliary shoots which do not become fully developed and are borne in the axils of the old leaves which have dropped off. Both chupon and fan branches bear flowers. The flowers are small, regular and hermaphrodite, being both male and female and, paradoxically, appear structurally adapted to prevent pollination.

FERTILISATION

The pollination mechanism of cocoa is not as yet fully understood. A large number of flowers is produced and it has been estimated that only about 5 per cent are fertilised, the other 95 per cent being

shed the day after opening. No scent or nectar is produced by the flower and the pollen is sticky and well enclosed, thus minimising the possibility of wind pollination. Investigations have shown that pollination is effected by insects but the picture is as yet incomplete.

To complicate the fertilisation question still further, there are two kinds of cocoa trees:—

(1) *Self-compatible*—On a self-compatible tree the flower can be pollinated by its own pollen or that of another self-compatible tree and normal ovule development then takes place.

(2) *Self-incompatible*—The flower of a self-incompatible tree must be pollinated by pollen from another tree for normal ovule development to take place. For self-incompatible types it is therefore necessary to have a mixed population of trees so as to ensure pollination.

The compatibility of a cocoa tree is important, especially when vegetative propagation and breeding are considered. If a high-yielding, self-incompatible tree is multiplied vegetatively by means of cuttings and then planted out in a mono-clonal block there will be little chance of getting any yield owing to the lack of pollinators which should be present in the ratio of one pollinator to every three incompatibles. With vegetatively produced clones it is always the best policy to plant a mixture of clones in a plantation in order to guard against this incompatibility.

FRUIT

The pod takes about six months to mature and it is generally possible to find flowers and pods on trees at all times of the year. In Fiji the peak months for fruit maturity are July–October; in areas where there is even temperature and even distribution of rainfall throughout the year, fruiting may continue all the time.

Within the first 6–8 weeks of their development many of the young pods, or "cherelles", wilt, turn black and dry up. This wilting is not a symptom of disease as the cause is physiological rather than pathological. The cause of cherelle wilt is thought to be competition for water and nutrients between the developing pods themselves and also between the pods and leaves. Cherelle wilt can be regarded as the cocoa tree's natural way of thinning its pods to the number that it can develop to maturity with the nutrients and water at its disposal, without over-bearing and exhausting itself. The incidence of cherelle wilt is also correlated with certain auxins, or growth factors, developed by the cocoa tree. When a pod has reached 11–12 weeks of age it is normally no longer likely to be lost by cherelle wilt.

The pod is berry-like but not succulent and may contain some 20–40 seeds coated with a sweet mucilage. The seed has no dormant period and should therefore be planted fresh and not dried. On germination, the root radicle will emerge from the rough or blunter end of the seed which, in the pod, is attached to the central core or placenta. This end should be pointed downward when planted so as to ensure the development of a straight trunk.

THE ROOT

The root system can be divided into two parts:—

(1) The tap root and its terminals; these penetrate the lower layers of soil in search of both moisture and nutrients and, in deep, friable soils, have been known to reach a depth of 10 feet.

(2) The superficial lateral roots; these extend 10–20 ft on all sides of the trunk and give rise to the fine fibrous rootlets that grow up toward the ground level. These rootlets search for nutrients and water in the humic layers of the top soil which are formed by the decomposition of leaves, twigs and branches of the cocoa and shade trees,

On marginal cocoa soils, e.g. Waidina Clay, where tap root development is restricted, it is essential to build up an organic blanket on the surface in which these lateral feeding roots can develop fully and supply the tree with its nutrient requirements. Clean weeding and removal of leaves, twigs, etc., on such soils should never be practised.

Plate 3. Seedling Cocoa (Lafi No. 7), 6 years old, Naduruloulou *Photo—P.R.O.*

VARIETIES

ORIGINAL USE OF THE TERMS CRIOLLO, FORASTERO AND TRINITARIO

Up to the 19th Century, the only type of Cocoa known was grown in Venezuela; this was called Criollo or native cocoa. The variety was characterised by pods which were long, deeply furrowed, prominently pointed, thin walled and, in some cases, conspicuously warty. The seed was plump and almost round in cross section while the cotyledon colour ranged from white to pale violet.

After 1825, another type of cocoa called Forastero was introduced into Western Venezuela from Trinidad; the pods were shorter and relatively broader, much less pointed, less conspicuously furrowed and less warty. The seed was flattish-oval in cross section with a dark purple cotyledon colour. This cocoa, being of foreign origin was called *"Forastero"* or *"Trinitario"*, i.e. the cocoa from Trinidad. Thus at this period Forastero and Trinitario were synonymous terms although this is not the position today. The original meaning of the terms Criollo and Forastero (Trinitario) is now lost although they are still in regular use.

PRESENT DAY MEANINGS OF THE TERMS CRIOLLO, FORASTERO AND TRINITARIO

Criollo—This type of cocoa has the characteristics of the native Venezuela Criollo of old, i.e. pods deeply ten-furrowed, very warty and conspicuously pointed; pairs of furrows come together at the point to form five ridges; the pod wall is thin and easy to cut; the seeds are plump and round in cross section and the fresh cotyledon is white to pale violet in colour.

The beans ferment quickly and tree yields are comparatively low. The chocolate flavour obtained from this cocoa is delicate in character and certain manufacturers regard the quality of Criollo cocoa as the finest of the fine.

Plate 4. Cocoa pods and flowers, strongly Criollo type *Photo—C. Walker*

Photo—P.R.O

Plate 5. Seedling cocoa, Trinitario type, 6 years old, Nadururloulou

Forastero (*Amazonian*)—This group makes up the bulk of the cocoa produced in the world today and includes the cocoas of Brazil and West Africa.

The pod is inconspicuously ridged and furrowed; it is smooth and round-ended or bluntly pointed. The pod wall is relatively thick with a woody layer, making it difficult to cut. The seeds are more or less flat and the fresh cotyledon is dark violet or even black in colour. The trees are hardier and heavier yielders than those of Criollo origin and the beans take longer to ferment.

The Forasteros may be termed the ordinary or strongly-flavoured cocoas of the trade. Botanically, the "Cacao Nacional" of Ecuador belongs to this group but by the trade is classified as a fine cocoa in the Trinitario group.

Trinitario—Today this term is applied to the type of cocoa that has evolved from the hybridization of the Criollo and Forastero types. It represents a hybrid population which is most heterogeneous and complex, exhibiting a whole range of characteristics ranging from Criollo through to Amazonian Forastero. A single pod may bear the complete range of external characteristics from Amazonian Forastero to Criollo, while the cotyledon colour of the seeds of a pod showing the external characteristics of Amazonian Forastero may range from white to deep violet.

To this group, together with the Ecuador Cacao Nacional, belong the fine cocoas produced by Trinidad, Ceylon, Indonesia, Papua-New Guinea and Samoa.

The cocoa population which exists in Fiji today, and which has been used for all cocoa plantings carried out since 1953, belongs to this Trinitario complex group. It is therefore anticipated that, for the first five years at least, any further commercial quantities of cocoa produced in Fiji will be similar in quality to that of Trinidad, Ceylon, etc.

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THE SOIL REQUIREMENTS OF COCOA

BY L. W. HARWOOD AND J. W. McPAUL

A good cocoa soil is one that is fertile, deep, freely drained and well-structured, with good moisture-holding capacity and possessing all the conditions suitable for proper root development. It should contain an adequate supply of organic matter and be slightly acid to neutral in reaction. A relatively high clay content is necessary since it provides an insurance against fluctuating moisture conditions. However, the clay must not be so heavy as to impede internal drainage or soil aeration. Depth of the water-table is important; whilst cocoa can withstand periodic flooding, the permanent water-table should not be less than 2 ft. 6 in. to 3 ft. below the surface.

Some of these points will now be discussed in detail.

DEPTH OF SOIL

A good, deep soil is required to ensure an adequate moisture supply throughout the year, particularly in parts of Fiji where abnormally dry conditions may be experienced in June, July and August. Adequate depth is necessary so that a good root system may be encouraged. If the soil is shallow, the tap root cannot develop properly and it is unlikely that sufficient moisture will be taken up to support the cocoa tree during periods of little or no rainfall. The need for adequate depth in the drier zones of the Colony cannot be overstressed. In the wet zone, however, where the problem may well be the disposal of surplus water rather than its retention, such depth may not be so essential.

SOIL STRUCTURE

Where the soil does not have good structure roots can never develop a satisfactory distribution, size and shape. One of the main agents for improving soil structure is organic matter which helps to keep a clayey soil friable and give a sandy soil better water-holding capacity.

In the tropics, structure is best developed in those soils with a high humus content. Good structure is seldom found in poorly drained soils; this is due to poor aeration which affects the chemical and biological processes in the soil, both of which influence the development of structure.

ROOT DEVELOPMENT

The cocoa plant has a tendency to push out lateral roots after the tap root has been established, the extent of this tendency depending on the soil. In soils with a high organic content, these lateral roots tend to turn upwards and obtain their nutrients from the humic zone. In such a soil lateral root development may be found well below the surface. However, in poorer soils, few lateral roots develop in the impoverished subsoil.

Adequate root room is essential for the proper development of roots. Stunted taproots are normally found in those soils which are shallow or have a high water table, or have an impervious clay subsoil. In deep, well structured soil, root development can proceed normally.

SOIL FERTILITY

So far only the physical properties of the soil have been considered, i.e. the depth, drainage, structure and texture. Some attention must now be given to the nutrient status of cocoa soils.

In a tropical climate, where high temperatures and heavy rainfall prevail, a good friable soil is the exception rather than the rule. Tropical soils are subject to two opposing forces—the rapid weathering of rocks caused by high temperatures and heavy rain on the one hand and the leaching of nutrients from the soil, as a result of the heavy rainfall, on the other. The rapid weathering of rocks causes mineral foods such as phosphate, potash, calcium, magnesium and trace elements to be continually added to the soil and, in the absence of leaching, this would mean a rapid build-up of available plant nutrients. However, movement of water through the soil carries these beyond the reach of most plant roots and these nutrients therefore become unavailable to the plant.

Once we have realized that both rapid weathering and leaching are always functioning in tropical soils, we can then understand that only those soils with special mechanisms for continual replacement of readily available nutrients can have the permanently high nutrient status most suitable for cocoa.

These special mechanisms fall into four categories:—

(*a*) *Alluvial Movement*—This occurs when rivers and streams carry down debris, silt, organic matter and partially weathered rock material during floods. These materials are dumped on the river banks and form the alluvial soils which are amongst the most fertile in the Colony. Unfortunately, they only form limited areas along most streams, but more extensive areas are to be found along the banks of the main rivers. Alluvial soils are frequently rejuvenated by fresh deposits of transported material

The heavier and coarser material carried by floods is deposited adjacent to the river and forms a " levee bank " while the finer clay material is carried to the " flood plain " beyond this levee. This plain is generally unsuitable for cocoa as the soil lacks the necessary physical properties, being badly drained and having a heavy texture. The soils of the levee bank, however, are ideal, being well drained and having suitable texture and structure for cocoa.

(*b*) *Colluvial Movement*—This takes place where top soil and organic matter are carried down slopes and deposited at their bases. This movement often results in the formation of a deep soil derived from an accumulation of top soil and the soil so formed may be quite fertile. However, such soil, where found in the very bottom of gullies or valleys, is usually subject to water-logging and is therefore unsuitable for cocoa unless it is drained. Apart from this, the colluvial soils of the lower slopes are generally suitable for cocoa growing.

Colluvial soils are widespread and occur in varying extent wherever there are hills and slopes. Although widespread, they are generally of very limited extent in any one locality.

(*c*) *Young Soils*—Some of the islands of the Fiji Group have been formed in more recent geological times. Examples of these are Taveuni, Koro and other islands of the Lomaiviti group. The soils of these islands still contain numerous rocks and boulders which are actively weathering, thereby providing a continuous supply of nutrients. Leaching is, of course, going on but is favourably balanced by rapid mineral decomposition of the rocks.

These are the areas offering the highest potential for crop development. Soils receiving their nutrients in a similar way are to be found in parts of Vanua Levu and other islands of the Group.

(*d*) *The Nutrient Cycle*—This mechanism is again mentioned in the article on Cocoa Nutrition which follows later in the *Journal*. Briefly, it is the process whereby large trees with deep roots are able to absorb nutrients which have been leached deep into the soil; these nutrients are conveyed to the leaves and, later, returned to the soil as a result of leaf fall and decomposition. By this means, a cycle is set up so that, as nutrients are released into the soil, they are reabsorbed by the plants. This mechanism offsets the nutrient depletion caused by leaching and explains why soils under forests are always much more fertile than similar soils which have been cleared for some time. Thus it more or less explains one of the virtues of shifting cultivation. After clearing a forested area, excellent crops may be grown for a time; however, these become progressively less productive so that, after about the third year, the soil has deteriorated to such an extent that the need for rehabilitation becomes apparent. After removal of the forest there is no longer an extensive root system to capture the available nutrients which are, consequently, soon leached beyond the root zone of most plants.

Cocoa, however, favours the utilization of such forest land in that it can be interplanted with the forest trees so that at no time is the land laid bare. In time the cocoa trees themselves become reasonably large with extensive root systems so that, as the forest shade trees are gradually thinned, the cocoa takes over and maintains the nutrient cycle.

From the four preceding classifications it will be seen that good cocoa soils will be found adjacent to the main rivers and on the lower slopes of hills in the wet and intermediate climatic zones. These, with the islands of Taveuni, Lomaiviti and the windward side of Vanua Levu, where young soils of volcanic origin occur, offer the best prospects for large-scale development.

SELECTION OF SOIL

Before spending money on planting cocoa, the farmer should satisfy himself that the soil of the selected area is suitable. A knowledge of the crop history of the selected area is desirable because experience has shown that it is a waste of time and money to plant cocoa on land which has been regularly cropped. Forest conditions must be re-created on such land before it may be used for cocoa.

Any examination of the soil by digging pits will give the farmer a good idea of the soil depth, structure, texture, and drainage. Blue or grey colourations in the soil will indicate permanent waterlogging. Red or brown mottling in the soil profile denotes intermittent wetting and drying, showing that at some time the soil was waterlogged. If the zones of permanent and intermittent saturation are close to the surface then the soil is obviously unsuitable for cocoa.

By examining the appearance, depth, and feel of the soil an experienced farmer should be able to assess its suitability for cocoa. The annual rainfall and its distribution, the slope of the land, its fertility and previous crop history should also be considered before a final choice is made.

Soils which are shallow, expecially those which have been developed over limestone, such as the Rendzina soils of Serua, should not be selected. The coralline flats near the seashore of the main islands are particularly unsuitable, especially where the coral rock is close to the surface. Excessive calcium in the surface soil restricts the uptake of potassium and favours further uptake of nitrogen, leading to excessive absorption of nitrogen and consequent nutrient unbalance.

Eroded and truncated soils, in which the rich organic layer has been removed, should never be used for cocoa growing.

In the selection of a cocoa soil due consideration must be given to its aspect or situation.

Heavy winds can cause physical damage to the trees by removing flowers and injuring branches, while breezes blowing in from the sea may contain salt which is detrimental to cocoa. When in doubt, the farmer should arrange for the Department of Agriculture to take soil samples in order that advice on the nutrient status and requirements of the soil can be given. The pH, or reaction of a calcimorphic soil, that is, a soil developed from rocks rich in calcium, will indicate whether it may be used for cocoa. Cocoa does best in soils with a pH between 6·0 and 7·2; whilst it will grow in soils that are much more acid, i.e. lower than pH 6·0, excessive alkalinity—above pH 7·2—must be avoided.

The Carbon-Nitrogen ratio of the soil—especially of the top 6 in.—is a valuable indication as to its suitability for cocoa; a C/N ratio of 10 is regarded as a critical figure. A high C/N ratio in the top soil is a reliable indication of good potential productivity whilst a low C/N ratio may suggest a condition associated with eroded, truncated or overcropped soils.

Reconnaissance soil surveys, carried out by Wright and Twyford, have revealed the presence of large areas of potential cocoa land and these surveys have provided valuable basic information for land development. However, before development of any particular area is envisaged, it should first be subjected to a careful detailed examination.

It is not overestimating the position to say that 75 per cent of all failures with tropical and sub-tropical crops are due to the original choice of unsatisfactory soils.

COCOA PLANTING

BY L. W. HARWOOD

The farmer, having selected his area for planting, should carefully note the following points:—

(1) Shade is required throughout the life of the cocoa tree and especially in its young stages.

(2) Where forest cover or mature coconuts do not exist, or cannot be used to provide permanent overhead shade, the necessary ground, temporary, and permanent shade which is planted instead must be sufficiently developed to provide adequate protection for the young plants before any cocoa is planted.

(3) A well distributed rainfall and protection from wind are essential. If the area selected for planting is not properly sheltered, an adequate system of windbreaks should be planted and established before any attempt is made to plant cocoa.

(4) The critical stage in the development of the crop is at the age of 3–5 years, when the cocoa plants have outgrown the ground and temporary shade and the planted shade trees are not sufficiently developed to provide adequate shade. In order to reduce this critical stage to the minimum, permanent shade trees should be planted 1–2 years before planting out the cocoa.

SHADE

There is considerable difference of opinion as to the need for permanent overhead shade. Some workers consider that cultivation and high manuring may reduce the need for shade; also, although cocoa is ecologically a tree of the lowland tropical forest, its natural environment does not always provide the best conditions as it is established that overshaded trees give reduced yields. When no permanent overhead shade is provided, closer spacings, varying from 6 ft x 6 ft to 9 ft x 9 ft, are generally used. Shaded cocoa is usually planted at spacings of 12 ft x 12 ft to 18 ft x 18 ft.

In Fiji, cocoa must be established under permanent overhead shade. This may be provided by thinned forest, mature coconuts, or planted leguminous trees. The use of permanent shade is recommended because few farmers could afford to fertilize heavily during the unproductive years of establishment. Moreover, shade is necessary for entomological reasons because of the depredations of the Rose Beetle (*Adoretus versutus*) which attacks unshaded cocoa.

A uniform spacing of 15 ft x 15 ft is recommended for Fiji conditions. Rooted cuttings can be planted at spacings varying from 8 ft x 8 ft depending on the soil.

PREPARATION

The method of preparing the land for the planting of cocoa will depend materially on the climatic and soil conditions of the district in which the farmer resides and the capital and labour force at his disposal.

The essential principles of cocoa planting are to provide close and protected conditions for the young cocoa, and the necessary overhead shade for its subsequent development.

The following methods of preparation have been used in Fiji:—

(1) Traditional West Indian.
(2) Establishment under thinned forest.
(3) Establishment under mature coconuts.
(4) Establishment under planted leguminous shade.

Figure 1

PLANNED LAYOUT SHOWING TRADITIONAL WEST INDIAN METHOD OF ESTABLISHING COCOA

```
B . X . B . X . B . X . B . X . B
. . . . . . . . . . . . . . . . .
X . O . X . O . X . O . X . O . X
. . . . . . . . . . . . . . . . .
B . X . B . X . B . X . B . X . B
. . . . . . . . . . . . . . . . .
X . . . X . . . X . . . X . . . X
. . . . . . . . . . . . . . . . .
B . X . B . X . B . X . B . X . B
. . . . . . . . . . . . . . . . .
X . O . X . O . X . O . X . O . X
. . . . . . . . . . . . . . . . .
B . X . B . X . B . X . B . X . B
```

B = Bananas at 15 ft x 15 ft.
O = Permanent overhead shade at 30 ft x 15 ft.
X = Seedling cocoa at 15 ft x 15 ft.
. = Dalo, cassava, pigeon pea, etc.

Alternatively, in cases where closer spacings than the above are used, bananas are generally planted 11 ft apart in the rows as bananas at 15 ft x 15 ft do not, under certain circumstances, provide sufficient temporary shade.

Table 1 shows the estimated cost of establishing and maintaining one acre of cocoa, until it comes into bearing at approximately four years of age, using the traditional West Indian method and assuming that all planting material has to be purchased and all labour employed is paid at the current rate of eleven shillings *per diem*.

TABLE 1

ESTIMATED COST OF ESTABLISHING 1 ACRE OF COCOA USING THE WEST INDIAN METHOD

	Seedling cocoa			Rooted cuttings		
	£	s.	d.	£	s.	d.
Preparation and planting..	215	4	0	235	14	0
2nd year	37	11	0	37	11	0
3rd year	37	11	0	37	11	0
4th year	37	11	0	37	11	0
Totals ..	£327	17	0	£348	7	0

It must be pointed out that a considerable proportion of the establishment costs may be offset by the sale of ground provisions and bananas, the planting of which is an essential feature of this method. Some two years before the cocoa is to be planted the selected area should be clean felled and leguminous shade trees planted. Nine months before the estimated planting date bananas are planted to provide the necessary temporary shade. About three months later, the shade trees and bananas are interplanted with crops such as Dalo (*Colocasia esculenta*), Cassava or tapioca (*Maniho*) *utilissima*) and Pigeon peas (*Cajanus cajan t* to provide ground shade.

The cocoa seedlings are planted out as soon as the close and protected conditions necessary for the young cocoa have been attained. At around the age of 3 years the ground shade has become sufficiently reduced for the permanent overhead shade to take over its proper function,

This method has not proved popular in Fiji because of the effort and expense involved.

Plate 6. Seedling Cocoa under Malayan Dwarf Coconuts. Note lower leaves damaged by Rose Beetle

Photo—P.R.O.

(2) Establishment under Thinned Forest

This method has proved attractive to the Fijian farmer. The smaller trees and scrub are removed, leaving the larger trees to provide shade and protection for the soil. With the introduction of light there will be a rapid germination of tree seedlings which will provide the necessary ground shade. Over-exposed areas should be planted up with leguminous trees to provide a degree of controlled shade.

Establishment under thinned forest is particularly valuable in the drier parts of the Colony, where removal of the natural cover may result in erosion and the loss of the valuable top soil and forest litter. Although used successfully in the wet zone it is not recommended for areas where the soils are poorly drained.

The danger of root and virus diseases detracts from this method which, however, has many practical advantages, especially for the farmer with limited capital.

(3) Establishment under Mature Coconuts

Interplanting of mature coconuts has proved a popular, inexpensive and efficient method of establishing a cocoa plantation in Papua-New Guinea. It is being tried, so far with success, on the island of Taveuni, where soil conditions for cocoa are ideal.

For best results, the coconuts to be interplanted must be over five years of age so that sufficient overhead shade for the young cocoa will be provided.

Temporary leguminous shade should be established some time before planting out the cocoa. Alternatively, the young plants should be protected from the sun and wind by shelters made from coconut fronds.

Coconuts spaced 28 ft x 28 ft or 30 ft x 30 ft on the square or triangle should provide adequate overhead shade for cocoa. However, in many areas of suitable cocoa soils the palms are not planted to any set spacing and will require considerable thinning before cocoa can be planted.

Figure 2

Planned Layout of Coconuts Planted 30 ft x 30 ft on the Square Interplanted with Cocoa

```
O  X  O  X  O  X  O
:  :  :  :  :  :  :
X  X  X  X  X  X  X
:  :  :  :  :  :  :
O  X  O  X  O  X  O
:  :  :  :  :  :  :
X  X  X  X  X  X  X
:  :  :  :  :  :  :
O  X  O  X  O  X  O
:  :  :  :  :  :  :
X  X  X  X  X  X  X
:  :  :  :  :  :  :
O  X  O  X  O  X  O
```

Figure 3

Planned Layout of Coconuts Planted 30 ft x 30 ft on the Triangle Interplanted with Cocoa

```
O  X  X  X  O  X  X  X  O
:  :  :  :  :  :  :  :  :
X  X  O  X  X  X  O  X  X
:  :  :  :  :  :  :  :  :
O  X  X  X  O  X  X  X  O
:  :  :  :  :  :  :  :  :
X  X  O  X  X  X  O  X  X
:  :  :  :  :  :  :  :  :
O  X  X  X  O  X  X  X  O
:  :  :  :  :  :  :  :  :
X  X  O  X  X  X  O  X  X
:  :  :  :  :  :  :  :  :
O  X  X  X  O  X  X  X  O
```

O = Coconuts at 30 ft x 30 ft or 28 ft x 28 ft.

X = Cocoa at 30 ft x 30 ft or 28 ft x 28 ft in the coconut rows and 15 ft x 15 ft or 14 x 14 ft between the rows of palms.

: = Temporary leguminous shade, e.g. Dadap, Vaivai (*Leucaena glauca*), pigeon pea, "Madre de Cacao" (*Gliricidia maculata*), etc.

The establishment and maintenance costs involved in bringing one acre of interplanted cocoa into bearing, assuming that all planting material has to be purchased, labour employed at current rates and fertilizers applied, are estimated at £73 for seedling cocoa and £167 for rooted cuttings, as set out in Table 2.

TABLE 2

Preparation and Planting	Seedlings	Rooted cuttings
	£ s. d.	£ s. d.
1st Year—		
Planting material including purchase of seed, pots, construction of temporary nursery and labour	3 10 0	40 0 0
Lining and holing ..	2 0 0	3 0 0
Shade establishment and planting of cocoa ..	6 10 0	10 0 0
Weeding, mulching and maintenance of shade	3 10 0	6 0 0
Fertilizers	10 13 0	21 0 0
Total 1st Year ..	£25 13 0	£80 0 0
2nd Year—		
Manipulation of shade, weeding mulching, pest and disease control ..	5 0 0	8 0 0
Fertilizers	10 13 0	21 0 0
Total 2nd Year ..	£15 13 0	£29 0 0
3rd Year	15 13 0	29 0 0
4th Year	£15 13 0	£29 0 0

Where fertilizers are not used establishment costs would be reduced to £30 per acre for seedling cocoa and £83 per acre for rooted cuttings.

(4) Establishment under Planted Leguminous Shade

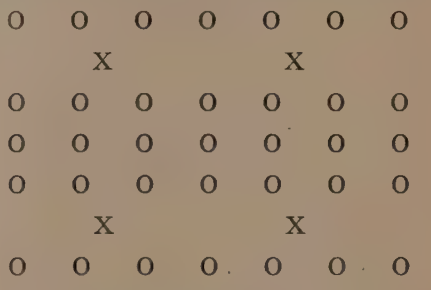
An efficient method of establishment, especially for rooted cuttings, is used at the Cocoa Station, Naduruloulou.

Leguminous shade of Dadap and *Desmodium gyriodes* in combination, or *Gliricidia maculata*, is planted in rows in the clean-felled area. A close spacing of 5 ft x 5 ft on the square is recommended so that early cover of the land will be achieved.

Regular topping of the shade will cause it to spread, and if planting is carried out at the end of the dry season or the commencement of the wet season, sufficient shade for the young cocoa will soon be available. Dadap or *Gliricidia maculata*, if properly controlled, will provide excellent temporary or permanent shade. Careful manipulation and removal of excess shade will become necessary as the cocoa grows.

Figure 4

PLANNED LAYOUT SUITABLE FOR PLANTING ROOTED CUTTINGS UNDER ESTABLISHED SHADE



O = Leguminous shade at 5 ft x 5 ft.
X = Cocoa at 15 ft x 15 ft.

This method is also suitable for clonal nurseries where the exclusion of up to 50 per cent of sunlight is required. In such nurseries rooted cuttings are planted out at 5 ft x 5 ft so that the maximum yield of cuttings will be available for propagation and, later, thinned out to 10 ft x 10 ft when the need for the nursery no longer exists.

This system is recommended for the rehabilitation of cocoa which has been overexposed during its early stages, and for the re-creation of forest conditions in Fijian gardens or forest land which has been cleared. Regular topping of the shade provides a mulch which is essential for the rehabilitation of the soil and the proper maintenance of the cocoa.

The estimated cost of bringing one acre of cocoa to the age of four years is shown in Table 3; this amounts to £187 for seedling cocoa and £295 for rooted cuttings:—

TABLE 3

	Seedlings			Rooted cuttings		
	£	s.	d.	£	s.	d.
1st Year—						
Clearing	11	0	0	11	0	0
Lining	2	15	0	4	8	0
Holing	3	17	0	6	1	0
Cutting and planting shade	7	14	0	7	14	0
Purchase of planting material (cocoa) ..	6	0	0	54	0	0
Planting cocoa	3	6	0	6	12	0
Supplying cocoa . ..	1	2	0	2	4	0
Weeding, mulching and control of shade ..	13	4	0	13	4	0
Pest and disease control	3	6	0	3	6	0
Fertilizers	7	10	0	15	0	0
Roads and Bridges ..	8	5	0	8	5	0
Drains	5	10	0	5	10	0
Contouring	5	10	0	5	10	0
Total 1st Year ..	£78	19	0	£142	14	0
2nd Year—						
Replanting cocoa ..	1	2	0	1	2	0
Weeding, mulching and controlling shade ..	13	4	0	13	4	0
Pruning	3	6	0	3	6	0
Pest and disease control	3	6	0	3	6	0
Fertilizers	15	0	0	30	0	0
Total 2nd Year ..	£35	18	0	£50	18	0
3rd Year	£35	18	0	£50	18	0
4th Year	£35	18	0	£50	18	0
Totals	£186	13	0	£295	8	0

From the foregoing, it will be seen that land for cocoa planting may be prepared in a variety of ways. There appears to be little doubt that the interplanting of mature coconuts is the most satisfactory method for the copra planter, as the costs of establishment are considerably less than those of alternative methods, other than planting under thinned forest, both in terms of money and labour.

TEMPORARY SHADE

Whatever form of temporary or ground shade is used, this must be removed as the cocoa grows. Establishment costs may be considerably reduced by the use of economic food crops such as Bananas, "Dalo", Tapioca or Cassava, "Dalo ni tana", "Yaqona" and Pigeon peas which may be sold or used as rations.

Dadap, "Madre de cacao" or *Gliricidia*, and *Desmodium gyriodes* make excellent temporary shade, being easy to establish and remove and providing a wealth of mulching material.

PERMANENT SHADE

When permanent leguminous shade is used it should be planted at a close spacing so that a quick cover may be provided and later gradually reduced as the cocoa grows and comes into bearing. It is not possible to lay down hard and fast rules as to the degree of overhead shade that cocoa requires as this will depend very materially on the climatic conditions, soil fertility and topography of the selected areas.

It must be recognised that young cocoa requires shade, and it is only as the tree approaches maturity that the shade may be reduced.

Dadap, which is easy to establish and control, appears to be the best of the leguminous shade trees available. "Drala" (*Erythrina indica*) may also be used but is inferior to Dadap because of its thorny habit. *Albizzia falcata*, which grows rapidly and provides the ideal canopy for cocoa, cannot be recommended because it is brittle and liable to cause extensive damage by falling branches during hurricanes and strong winds. "Vaivai" could be used in the wet zones, but is not advocated for the dry areas where, because of its prolific seeding, it may be difficult to control.

WIND-BREAKS

Essential as it is grow or provide shade for cocoa, this not enough; generally speaking, protection from wind is as necessary as shade, particularly in areas subject to strong winds at certain seasons and in areas which are subject to occasional hurricanes. Windbreaks are as necessary in Fiji as in other cocoa producing countries.

Strong winds sweeping through a plantation cause obvious damage by breaking the branches of the cocoa and of the shade trees; they also remove many flowers and so cause reduction in yield. But even moderate winds have a drying effect on the soil and can make it impossible to maintain, or even to attain, the moist, still, humid atmosphere that cocoa requires.

The tall, permanent shade trees undoubtedly provide a fair amount of protection from wind; but they do not give protection where it is most needed, at and within a few feet of ground level; it is necessary, therefore, to provide windbreaks around the edges of the plantation and, in some cases, at intervals within the plantation itself.

Where cocoa is to be planted under thinned forest, it is advisable to leave a strip of forest at least fifty feet wide on the sides of the area most subject to wind—and certainly on the side facing the prevailing wind; it is important also not to thin out the trees or to plant cocoa along the top of any prominent ridges within the plantation area. Where a strip of forest has not been left, or cannot be left, the only alternative is to provide protection by planting a windbreak.

Not only must windbreaks be situated at right angles to the prevailing winds but they must themselves be capable of withstanding strong winds. The trees used should therefore be deep-rooted and not too dense in habit so that, while they can stand up to and deflect strong winds, they still allow a certain amount of wind to filter through.

In some cocoa growing countries the trees comprising the windbreaks are interplanted with trees having a lower habit of growth which eventually form close hedges, protecting the critical area of the plantation at and just above ground level. It is sometimes possible to use trees which themselves will produce an economic crop either of fruit or of timber, the latter being selectively felled and, of course, replanted. Thus, cloves (*Eugenia aromatica*) are useful as a tall windbreak while more than one species of coffee can be used as a lower storey windbreak.

In Fiji, tall windbreaks can be provided by mango (*Mangifera indica*), "Kavika" or Malacca apple (*Eugenia malaccensis*) and mahogany (*Swietenia macrophylla*); in Western Samoa extensive use is made of teak (*Tectona grandis*).

A lower storey windbreak can be established with plants such as Liberian and Robusta Coffee (*Coffee liberica* and *C. canephora*), Hibiscus spp., Annatto (*Bixa orellana*), *Aralia* spp. and "Vaivai" (*Leucaena glauca*).

PLANTING MATERIAL

Seedlings

These are raised for distribution to farmers in various parts of the Group. Planting out of seedlings is preferred to actual planting of seed at stake because this allows of better selection in the nursery. Moreover, the young trees may be transplanted when conditions for their permanent establishment are most suitable.

The raising and distribution of seedlings is normally controlled by the Department of Agriculture which makes free issues to bona fide farmers whose land is properly prepared for planting. The Department will, however, assist and advise farmers on the construction of nurseries and the raising of seedlings on their own properties.

Cocoa seedlings require shade and also protection from the wind and heavy rain. An inexpensive nursery shelter may be made using bush timber or bamboo posts covered with bamboos and coconut fronds spaced to exclude 25–50 per cent of the sunlight.

The potting mixture used on Departmental nurseries has proved very satisfactory; this is made up of 4 parts of slightly acid soil, 2 parts of mill mud or compost and 1 part of river sand. Where mill mud is unobtainable, a mixture of equal parts of well-decayed compost, top soil and river sand is recommended. The admixture of ½ oz. Cuprox, a commercial copper oxychloride dispersible powder, with every two cubic feet of the potting mixture will considerably reduce losses from soil-borne fungi.

Until recently, seedlings have been raised in bamboo pots 8 inches long and 4–5 inches in diameter with a drainage hole at the base.

These have now been replaced by polythene bags which have proved cheaper, easier to handle and much more satisfactory in every way.

When preparing the container, some fibre or gravel should be placed in the bottom to ensure good drainage. It is then filled to overflowing with the potting mixture, which is consolidated by tapping on a firm surface and then levelled off.

The seed should be carefully pressed into the soil with the blunt end, or hilum, pointing downwards, the top of the seed being just below the surface. Planting with the hilum upwards will result in the production of crooked and distorted seedlings.

The containers should be lightly watered once daily. It is especially important that they be protected from beating rain during the germination period which should be completed in 14–21 days. Daily waterings should continue until the seedlings are ready for distribution, although additional watering may be required by the older plants in hot, dry weather.

A composite spray of 2 oz. of Cuprox, 1 oz. of 50 per cent D.D.T. dispersible powder and ¾ oz. of White Spray Oil, in 3 gallons of water, applied every three weeks, gives good control over leaf eating caterpillars, cutworms, mealy bugs and fungus diseases in seedling nurseries. Severe outbreaks of Rose Beetle may be controlled by spraying with 1 oz. of Dieldrin 15 per cent Emulsifiable Concentrate in 3 gallons of water. The growth of backward seedlings may be improved by spraying with 6 oz. of Urea in 3 gallons of water.

The seedlings should be ready for planting out when they are about four months of age and when the second flush has hardened.

Rooted Cuttings

These have not yet been issued for sale to the general public, all available cuttings having been used for the planting up of clonal nurseries and clonal seed gardens on Departmental Stations. Rooted cuttings of selected local and introduced clones are propagated at the Cocoa Station, Nadururloulou, and will also be raised at the Cocoa Station, Nagigi.

The propagation of semi-hardwood fan cuttings allows of the rapid multiplication of high yielding trees. Plants raised in this manner are identical with the parent tree. Particular care should be taken in the management of parent trees from which cuttings are to be removed. The nutritional state of the parent plant and the amount of shade it receives are factors affecting the successful rooting of cocoa cuttings.

Cuttings, about 9 inches long, are taken from the nursery gardens in the early morning; they are then taken to the propagators and a fresh cut is made. The cut surface is dipped in rooting hormone, the lower leaves are stripped, and the upper leaves cut across so as to reduce the leaf surface by half; the cuttings are then placed in the sand of the propagating bin. They remain in the bin for up to one month, during which time they are kept in a completely moisture-saturated atmosphere.

After rooting, the cuttings are potted in baskets, or large pots, and placed in the hardening bins where they remain in a moisture-saturated atmosphere for an additional week. At the end of this period, the lid of the bin is raised every two or three days by a couple of inches so that, by the end of a further 14 days, the lid is wide open. Hardening is then complete.

The rooted cuttings in their containers are then placed under shelter in a nursery until ready for issue in about 3–4 months time.

Best results have been obtained with the Trinidad type propagating bins.

LINING

Whatever method of preparation is used, the selected area should be lined for planting. When thinned forest or mature coconuts provide the permanent shade this is a relatively simple operation. When, however, cocoa is being established under planted leguminous shade, with or without bananas or other ground cover, lining must precede the planting of the shade and the planting sites of the cocoa should be marked out when the lining for shade trees is being done.

Tree sites may be laid out on the square or the triangle, the latter method providing more trees to the acre. On hilly land, lines should be laid out on the contour. Any necessary drainage or contouring should be done before any shade or cocoa is planted. Altering the arrangement of drains or soil conservation measures is often difficult and costly once the crop has been planted.

HOLING

Holes should be wide rather than deep. A hole 2 ft square and 1 ft deep is a good size.

When removing the soil from the hole, the top soil and sub-soil should be kept separate so that the top soil may be used around the roots of the plant when filling in the planting hole. The addition of farmyard manure or well rotted compost to the planting hole will assist the early growth of the young plant.

PLANTING

The seedlings or rooted cuttings should be planted out in the field in the early morning or late afternoon and never when the sun is hot at mid-day. If possible, planting out is best done on a cloudy or drizzly day.

The plant, together with the soil in which it has been established, is removed from its pot or container and should be planted to the same depth as it was the nursery. The soil should be carefully packed around the plant in the planting hole, taking care that no depression, in which water can collect, is left around the base of the plant. A mulch of grass or decaying organic matter should be applied to the surface of the soil around the plant to prevent excessive evaporation.

AFTER-CARE

During the first two years after planting the control of weed growth and of the amount of ground and overhead shade are important operations.

The young cocoa should be circle-weeded regularly. The grass and weeds removed by weeding should be spread over the cleared area to protect the exposed soil from sun and beating rain. Farmers who have interplanted cocoa in coconuts can obtain an excellent mulch by spreading coconut husks, with the inside portion of the husks downwards, around the base of the plant. These will keep the soil moist, protect it from sun and rain and reduce weed growth.

When weeding, care should be taken to see that the stem and the surface roots are not damaged. Cuts can allow of the entry of secondary fungi, such as *Botryodiplodia theobromae*, which may cause the death of the tree.

Mulches are best applied before the onset of the dry season, as they conserve soil moisture. They are particularly valuable as they add organic matter to the soil and improve its structure. Well mulched soil provides a rich organic layer in which the surface roots may obtain the required nutrients.

Careful manipulation of both the temporary and permanent shade is necessary to provide approximately 25–50 per cent of full sunlight. The extremes of too much or too little light should be avoided as cocoa is very sensitive to its light requirements.

Any cocoa plants which die should be replaced as soon as possible because, as the canopy closes, the establishment of "supplies" becomes increasingly difficult.

Regular spraying to control the Rose Beetle will be necessary, and perhaps even the construction of barriers to reduce the damage caused by this insect.

PRUNING

The seedling plant produces a straight stem called the "chupon". When the plant is about 18 months old and the chupon is 3–5 ft high it ramifies into 3–5 fan branches which grow out almost horizontally, forming what is called the "jorquette". When these branches are sufficiently developed, the tree should be pruned so as to retain 3–4 fan branches.

The objects of pruning, which should be carried out regularly after the formation of the fan branches, are:—

(1) to shape the tree so that it consists of one chupon and 3–4 fan branches;

(2) to prevent additional chupons growing up through the jorquette;

(3) to facilitate the harvesting of pods which are carried on the main trunk and branches;

(4) to remove dead or damaged shoots.

A tree should never be pruned when it is flowering or fruiting as this will upset the metabolism of the plant.

GENERAL

In the third year no further ground shade such as dalo or cassava is required, though bananas and other taller forms of temporary shade will still be necessary and supplies should be planted where shade is inadequate.

As the cocoa tree grows and the canopy closes, the need for temporary shade will diminish and this should be removed when the permanent overhead shade provides sufficient protection.

Weeding and mulching should be carried out as required. As the canopy closes, weeding will be reduced to an occasional slashing but the need for mulching is ever present and this should be carried out whenever practicable.

Fertilizers are particularly valuable in the early stages of growth. Before applying these the cocoa should be circle-weeded to a distance of approximately 1 ft. beyond the periphery of the leaves. The material obtained from this weeding should then be spread evenly over the cleared area. If possible, additional mulching material from outside sources should be applied to bring the mulch up to a depth of 3–4 inches.

While the investigational programme is not sufficiently advanced to enable precise fertilizer recommendations to be made for the various soil types, the following mixture is a provisional recommendation and should give good results:—

8 parts by weight of Blood-and-bone
4 parts by weight of Urea
4 parts by weight of Superphosphate
4 parts by weight of Sulphate of Potash.

One pound of this mixture should be applied per tree every four months. If possible, the first application should be made under the mulch within the periphery of the tree. Later applications may be broadcast over the mulch, again over the outer circle of the tree.

Fertilizer recommendations will vary from time to time and farmers are advised to consult their local Agricultural Officers for up to date information on this important aspect.

Cocoa should come into bearing in its third or fourth year. Losses of pods from fungus diseases, such as Black Pod, can be quite serious in heavy rainfall areas, especially where the natural drainage of the soil is poor. Constant inspection of the trees to remove diseased cherelles or pods, to carry out routine pruning and shade manipulation and to check on the need for pest and disease control, is essential for proper development of the plantation.

Provided that the cocoa has been grown with adequate shade and has been carefully maintained, it should come into full bearing at about seven years of age and provide an annual income for many years. Its longevity and productivity depend very materially on the care and attention it receives during the early stages of development.

YIELDS

Yields depend on a variety of factors, including climatic and soil conditions, type of planting material and standards of preparation and management, and are difficult to predict. Well managed seedling cocoa should yield up to 5 cwt. of fermented and dried beans per acre per annum whilst higher yields may be anticipated from areas planted to rooted cuttings of high-yielding clones.

Photo—P.R.O.

Plate 7. Vegetative propagation of Cocoa ; rooted cuttings in hardening bin, Naduruloulou

PUBLICATIONS OF THE FIJI SOCIETY

The Transactions of the Fiji Society cover a wide range of subjects including anthropology, botany, ethnology, geology, history and zoology, with special reference to the research carried out in Fiji and in other Pacific areas.

Volume 5 of the Transactions of the Fiji Society is now available. This volume covers the years 1951 to 1954. Volume 6 of the Transactions will be available later in the year and will bring the publications of the Society up to the end of 1957. Orders are now being received for both volumes. The price per volume is twenty-five shillings (25s.) Fiji currency and this includes postage. (Please note that one pound Fijian (£1F.) is approximately equivalent to two dollars fifty cents ($2.50) U.S. currency.

Volumes 2, 3 and 4 of the Transactions are still available and the price is three pounds three shillings (£3 3s. od.) for the set of three volumes. Volume 1 is out of print.

Orders should be addressed to the Hon. Treasurer, Fiji Society, P.O. Box 358, Suva, Fiji.

THE PREPARATION OF COCOA

BY V. E. SILLS

When the cocoa farmer has successfully raised his trees to the stage of bearing pods his task of producing marketable beans is by no means over. On the contrary, the preparation of cocoa is beset with not a few difficulties, and in order to produce first-class fermented and dried beans plenty of understanding and patience is needed.

Let us look at it this way. The makers of chocolate and cocoa powder are the main consumers of raw cocoa and they naturally take a keen interest in the quality of this—what is today—expensive raw material. When purchasing cocoa the makers want to know two things: how much chocolate flavour they can get from it; and whether any unpleasant flavours or taints derived from bad processing are present. When as little as 4 per cent of mould-infected beans can ruin a consignment of cocoa on account of the mould-like flavour imparted to chocolate prepared from it, it is not surprising that the chocolate makers employ shrewd and observant buyers. Cocoa quality is indeed a factor of prime importance in the chocolate industry today.

DEFINITION OF QUALITY

What do we mean by good quality cocoa ? How is it prepared ?

Three main points have to be considered when discussing quality. Firstly, the chocolate maker requires cocoa of even grade, that is, one possessing unvarying quality. Secondly, he requires cocoa that will yield good chocolate flavour. Thirdly, the chocolate flavour should not be accompanied by strong ancillary flavours or by off-flavours frequently described by expert tasters as mouldy, earthy, hammy (smoky), cheesy and so on. On the other hand, provided the ancillary flavour is mild in strength and pleasant in character, this type of cocoa may actually be prized by a few chocolate makers who seek special flavours for particular brands of moulded chocolate bars. Such flavours are usually related to raisins, liquorice or caramel.

GRADE

Cocoa of even grade is a quality for which agents, factors and brokers are mostly responsible, especially in large cocoa producing countries. By a skilful blending of cocoas from innumerable sources these people render an important service to the cocoa trade. The farmer plays his part, too, by producing a certain standard of quality which the local buyer soon learns to associate with his name. The well-fermented cocoa of Accra (in Ghana), for example, owes its remarkable uniformity of quality to an extensive system of blending by local buying agents.

CHOCOLATE FLAVOUR

When we come to consider strength and character of chocolate flavour the strength factor at least is more or less decided upon when the farmer selects his cocoa planting material. The character of the chocolate flavour, however, is a different matter and is influenced by the manner in which the cocoa is processed.

Fortunately for the farmer, faults in processing, that is during fermentation and drying, can often be remedied by special treatment at the chocolate factory.

For example, under-fermented cocoa gives a harsh and bitter taste to chocolate when processed in the ordinary way, but by employing special processing techniques the chocolate maker can get rid of some of the unpleasant character. On the other hand, there is little he can do to improve over-fermented cocoa. Over-fermentation destroys chocolate flavour; once lost it cannot be recovered.

Other factors which have some influence in chocolate flavour development but which do not come under the direct control of the grower, except to a minor extent, concern climate, soil conditions and environment. Sunshine, rainfall, elevation, method of cultivation, fertilizers, shade, and so on, must all have some slight effect on cocoa quality although to what extent little is known.

To sum up, good quality cocoa may be defined as a product that has been well fermented and dried, and from which, by the action of roasting, a good chocolate

aroma and flavour can be produced; the flavour may be accompanied by a weak ancillary flavour such as is normally associated with cocoa, e.g. raisin, caramel or liquorice, but it must be entirely free from off-flavours.

OTHER CHARACTERISTICS

Much can be learned about the quality of cocoa beans from an examination of shape, colour and texture. Well-fermented cocoa is usually plump, while flat beans are frequently a sign of poor fermentation. Beans of good quality have an open texture with air spaces between the segments of the cotyledons; a hard or cheese-like texture denotes inadequacy of fermentation.

Chocolate-brown and cinnamon-brown colours are charateristic of well-fermented cocoas. Purple or gray colours suggest under-fermentation, although a small percentage of purple beans is not considered undesirable. In fact, it has been said that a sample of cocoa showing all chocolate browns may be suspected of being over-fermented, which, as previously explained, is a serious fault.

Reference should here be made to Plate 9, kindly supplied by Messrs. Cadbury Bros. Ltd., Bournville, clearly illustrating the various characteristics of cocoa beans.

There are many other criteria which are used to measure the quality of cocoa; moisture content, shell content, fat content, insect damage and so on. These will be discussed in more detail later on.

Plate 8. Seedling Cocoa, 4½ years old ; Wailevu, Vanua Levu *Photo—P.R.O.*

FERMENTATION AND DRYING

The Importance of Fermentation

To anyone who has tasted chocolate made solely from unfermented beans the essential part played by fermentation in the preparation of cocoa must be only too clear. Such chocolate possesses an intensely bitter and astringent taste which tends to mask what little chocolate flavour is present. From a chocolate manufacturer's point of view unfermented beans present other problems besides those connected with flavour. The shell tends to hug the nibs after the beans have been roasted and cracked between rollers; the nibs do not grind well and yields of cocoa butter are low. In fact, unfermented cocoa has very little value at all.

Fortunately for the chocolate maker the cocoa buyer has no difficulty in detecting the presence of unfermented beans in cocoa offered for sale; nor is it difficult to recognise under-fermented cocoa. Unfermented beans are usually flat in shape and, when cut with a knife, reveal a slate-like appearance. Similarly, under-fermented beans are often of hard and close texture while the colour of the cotyledons may vary from white (for Criollo types) to dark purple (for Forastero types).

The Process of Fermentation

In general terms, fermentation of cocoa consists of allowing a mass of fresh cocoa seeds to "heat up" naturally in suitably shaped containers for a period of several days with occasional turning. The heat of fermentation is produced by the action of of yeasts and bacteria on the sugar-rich, white pulp surrounding the fresh seeds; the sugar is converted into alcohol by the yeasts and the alcohol is changed into acids by vinegar-type bacteria. This microbial activity serves a double purpose by removing most of the mucilage from the outer coat of the seeds and by raising the temperature of the seeds sufficiently to kill them during the early part of the fermentation.

At the commencement of fermentation the seeds are normally alive and, as a result of the gradual rise in temperature, the germination processes are set in motion. After 24–36 hours most of the seeds die, caused by the combination of heat and acid. Important bio-chemical changes then occur inside the bean* which ultimately are manifested by the development of good chocolate flavour. Normally these changes are completed between the fifth and eighth days of fermentation, the exact time depending on whether the cocoa is of Criollo or Forastero origin.

In practice, the heap of seeds must be large enough and sufficiently well protected against loss of heat to reach a temperature of at least 112–113° F. (45° C.) after the second day of fermentation. For amounts of less than 300 lb. much difficulty will be experienced in this respect unless proper precautions are taken to prevent leakage of heat. Occasional turning of the mass of fermenting seeds is important because it provides the aeration required to encourage the growth of the more desirable types of bacteria. It is considered good commercial practice to turn the heaps every two days.

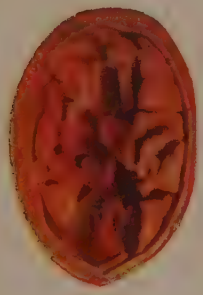
In the case where the cocoa farmer has only a small number of trees in bearing, such as would happen when young trees are just coming into bearing or when the total number of established bearing trees is small, there may be some difficulty in getting sufficient seeds together at any one harvesting to make a quantity big enough for a fermentation. To overcome this situation the farmer would be well advised, where possible, to join or to form a co-operative cocoa farmers' association. A local organization of this type could equip itself with a fermentary and central drying facilities for the benefit of many small farmers in the district.

During the course of fermentation, visible changes take place inside the bean which may be observed by cutting a few beans with a knife. When correctly fermented, the beans are plump and the seed coat separates easily from the enclosed cotyledons. Colour changes may be noted but the characteristic chocolate-brown and light brown colours of the dried bean are not developed until the subsequent drying stage is well advanced.

* It is customary to refer to fermented seeds as beans.

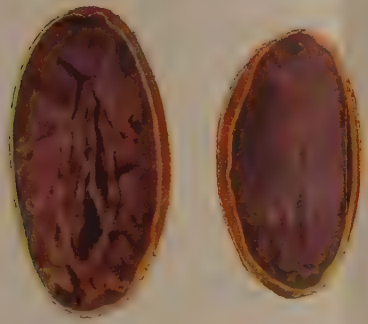
THE CHARACTERISTICS OF COCOA BEANS

WELL FERMENTED CRIOLLO



Cotyledons free in the shell and open.
Colour ; Cinnamon.

INSUFFICIENTLY FERMENTED FORASTERO (ACCRA)

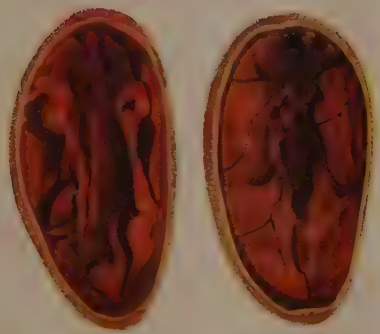


Cotyledons just opening and becoming free in shell.
Colour : Still containing purple.

MOULD INSIDE BEAN

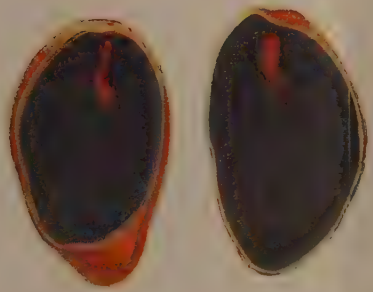
Mould growing on the cotyledons. The mould varies in colour.

WELL FERMENTED FORASTERO (ACCRA)



Cotyledons free in the shell and open.
Colour : Deep chocolate brown.

UNFERMENTED FORASTERO (ACCRA)



Cotyledons tightly packed and cheesy in texture.
Colour : Slaty purple.

INSECT ATTACK

Beetle attack indicated by clean hole in the shell. Moth attack indicated by frass entangled in web.

Prepared by Messrs. Cadbury Brothers Limited, Bournville

IMPORTANCE OF ADEQUATE DRYING

Having reached the end of a 5 or 6 day fermentation period the beans must be carefully dried. Drying serves a two-fold purpose. By reducing the moisture content of the wet bean to 8 per cent or less the bean is made impervious to the attacks of moulds and bacteria, and, provided the surrounding shell is intact, to the attacks of most insects. A second and less obvious purpose is that of completing the final phase of chocolate flavour development—one of the vital stages in the preparation of cocoa. During drying, and particularly in the latter stages, air comes into intimate contact with the internal parts of the bean. The oxygen of the air brings about certain bio-chemical changes which lead to the development of light-brown or chocolate-brown colours and what chemists refer to as the " precursors " of chocolate flavour. They are called precursors because it is not until the beans have been roasted that the characteristic aroma and flavour of chocolate are apparent.

Should the cocoa beans be dried too quickly, or at too high temperatures, the normal bio-chemical changes do not take place, with the result that when the beans are roasted a good chocolate flavour is not produced. Drying is therefore much more than a matter of just removing water so as to enable the cocoa producer to store his produce without fear of spoilage.

SUN DRYING VERSUS HOT-AIR DRYING

Two methods of drying cocoa are commonly practised in the Tropics—sun drying and hot-air drying. The peasant farmers of West Africa sun dry their cocoa on raised platforms made of bush sticks and covered with mats of palm fronds. In Western Samoa, along the road between the Satapuala Seadrome and Apia, a common sight in the villages is the array of small mats of cocoa spread out in the sun to dry. In fact, where small quantities of cocoa are required to be dried and there is adequate sunshine and a good drying wind, sun drying is a very practical and satisfactory solution. Even on a plantation scale, sun drying is practised extensively where conditions permit, as, for example, in Trinidad.

Hot-air drying has the advantage of speed and, of course, is independent of weather conditions. In the wet zone of Fiji, where cocoa plantings are concentrated, the hot-air drier is much to be preferred, since sun drying is impracticable for the greater part of the year. The climate is so unpredictable in this region that sun drying would certainly be a hopeless proposition for plantation scale production.

Using a natural ventilation type of hot-air drier, such as the Martin drier, cocoa can be dried in 24 to 36 hours. According to investigations carried out in West Africa by Messrs. Cadbury Brothers Ltd., Amelonado cocoa can be dried in 14 hours, using a forced draught of hot air heated to 176° F., without harming its chocolate making qualities. However, these probably represent the extreme limits of drying conditions for cocoa grown in West Africa and might be too severe for the more delicately flavoured types of cocoa grown in Fiji.

ACIDITY

The speed with which the cocoa is dried certainly has a marked influence on quality. It appears that the comparatively slow sun drying process provides an effective means of getting rid of unwanted acidity—acidity derived from bacterial action during fermentation. The faster hot-air drying method does not remove the acidity so effectively and, consequently, cocoa processors often employ supplementary measures to assist in the removal of the remaining acidity. For example, on the West Samoan Trust Estates the cocoa is first dried in large Martin driers, then lightly wetted and finally dried in rotary McKinnon driers. In New Guinea, the beans are not given the intermediate wetting but are transferred directly from Martin to McKinnon driers while still moist.

Powell (1958) of Cadbury Brothers' Research Department reports that the residual acid in hot-air dried cocoa is mainly acetic acid and is responsible for the fruity or " estery " flavours of unconched chocolate, that is to say chocolate that has not been fully processed in the factory. In other words, whereas laboratory-made chocolate

may have a fruity ancillary flavour, chocolate made in the factory from cocoa drawn from the same source may lose its fruity character during normal factory processing. On the other hand, if the natural acidity of the raw cocoa is very high, even conching may be of no avail.

CLEANLINESS

Mention was made earlier of the serious view taken by chocolate makers of taints and off-flavours present in cocoa. These may be caused by improper drying or fermentation, but can also arise from contact with materials contaminated with rancid oil, e.g. stale copra, or smoke, paint, chemicals, etc. The importance of cleanliness when handling cocoa cannot be stressed too highly.

METHODS OF PREPARATION

HARVESTING

The cocoa farmer is fortunate in one respect at least, and that is that he does not have to pick the fruit at an exact stage of ripeness as he would be obliged to do if he were producing, say, coffee, or vanilla. Cocoa pods take 5–6 months to reach maturity from the time of setting and the ripening process is a gradual one lasting three or four weeks. Harvesting need not therefore be more frequent than once a week or even longer, depending on the supply and minimum quantity of seeds required to operate the fermentary or to fill a fermentation box. Pods should be picked carefully when ripe; at the same time any diseased pods present should be removed and taken away to be destroyed.

Provided the pods can be looked after safely there is no need to open them immediately. In fact, some advantage is gained by keeping the pods for two or three days before opening them, and on plantations at the West African Cocoa Research Institute this practice is a general one. But where pilfering of pods is liable to occur it would be better, of course, to open them without delay.

As to whether the pods are opened on the cocoa farm or are conveyed direct to the fermentary depends on local conditions. On the West Samoan Trust Estates, for example, there is an excellent system of roads and paths, and consequently it is convenient to extract the seeds at the roadside within the vicinity of the plantation; the seeds are transferred to sacks which are picked up a short while afterwards by trucks and transported to the fermentary. The empty pods are allowed to rot and are returned to the soil to assist in maintaining soil fertility.

In order to extract seeds from the ripe pods it is customary to cut the pod about its circumference with a sharp knife and to break the pod open with the hands. Care should be taken not to cut the pod wall too deeply or some of the seeds will be damaged. Cocoa buyers object to beans with cut shells because of the risk of insect attack. The seeds are then extracted and separated from the central stalk—or placenta, as it is called. On no account should the placentae accompany the seeds to the fermentation boxes; the seeds which are stuck together should be separated before putting them into the fermentation boxes.

Care must be taken not to bring dirt of any kind into contact with the fresh seeds, and where a clean floor is not available it is usual for the pods to be opened over a layer of fresh banana leaves. If " wet " cocoa is conveyed in trucks care must be taken not to allow iron surfaces to come into contact with seeds. Not only does contact with iron cause the cocoa to turn black but the metal itself is quickly corroded by the acid present in the cocoa pulp. The washing down of truck interiors after carrying sacks of wet cocoa is therefore a point not to be overlooked.

METHODS OF FERMENTATION

Broadly speaking, the procedure used in various countries for the fermentation of cocoa varies only in detail, depending on the quantity to be fermented and on the cocoa farmer's private circumstances. In West Africa, for instance, the primitive peasant farmer usually builds a conical pile of seeds on a sloping piece of ground, covering it with banana leaves in an attempt to contain the heat generated by fermentation. Provided the heap is of a reasonable size, i.e. not less than 300 lb. and is turned once or twice during the fermentation, good

results are often achieved. But a better way is to ferment the cocoa in boxes lined with banana leaves and raised off the ground so as to permit the sweatings to drain away freely.

On a plantation scale of production the fermentation boxes are, of course, of large size and are usually housed in a draught-proof covered building. The fermentation boxes are mounted side by side in rows and are sometimes arranged in step-like fashion to take advantage of gravitational fall as a means of transferring the mass of beans from one box to the next. The fresh seeds are first placed in the box at the end of the row, and at regular intervals of one or two days are moved one box along the row. This movement ensures thorough mixing and aeration.

There is a definite limit to the size of box that can be used for cocoa fermentations, 5 ft by 4 ft by 3 ft being a common size in most large fermentaries. Anything bigger than this is likely to result in poor fermentations.

FERMENTARY AT NADURULOULOU

In 1958 a small fermentary and Samoan-type drier were erected at the Cocoa Station, Naduruloulou. The fermentary consists of three boxes, each 3 ft by 3 ft by 2 ft deep, raised in steps, with one removable side in each to permit of the transfer of beans by gravity. Each box holds about 800 lb. of wet beans, which is the right quantity to keep the adjacent drier in continuous operation. After intervals of two days the contents of the boxes are moved one stage along; in the meantime, precautions are taken to keep draughts away from the boxes, particularly as the quantities of beans concerned are small by normal fermentary standards.

The boxes are constructed of strong timber (local "Dakua") all joints being made with wood dowels; no nails of any description should be used. A few holes of $\frac{3}{8}$ inch diameter are made in the floor boards of the boxes to facilitate the escape of sweatings. The roof above the fermentary and drier is made of bush materials, but where a permanent roof is required for a larger fermentary, aluminium sheets are to be recommended. Galvanised iron sheets are quickly corroded by the acid vapour produced by fermenting cocoa and should not be used. The sweatings which seep away from the fermentation boxes are also of a corrosive nature, containing citric and acetic acids, and attack concrete floors unless these are treated or lined to resist the action of acids.

FERMENTATION TEMPERATURES

During fermentation the operator should keep a check on temperatures, especially when putting a new fermentary into commission. As explained previously, the temperature beneath the surface of the beans should reach at least 112–113° F. (45° C.) after the first 24–36 hours and should be checked by means of a suitable stem-type thermometer.

If temperatures fail to reach 112–113° F. (45° C.) more protection or insulation to prevent heat losses is probably required and steps should be taken to remedy this fault. A high temperature should be maintained from the second day until the last day of fermentation. Low temperatures, if permitted, may favour the development of less desirable types of micro-organisms which give rise to unwelcome foreign flavours in the cocoa.

DURATION OF FERMENTATION

The duration of fermentation varies according to the type of cocoa being fermented. Forasteros require 7 to 8 days of fermentation to secure the full benefit of the process. Criollos, on the other hand, may need as little as 2 days. Hybrid or "flavour" cocoas fall between the two extremes, 5 to 6 days being considered about optimum. With hybrid cocoas, the position is less satisfactory on account of the diversity of types, some being predominantly Forastero and others more Criollo. The result of fixing the time of fermentation for a mixture of hybrid cocoas is that a part of the cocoa is liable to be under-fermented and another part over-fermented. Unfortunately, there appears to be no satisfactory answer to this problem.

MODIFIED METHODS OF FERMENTATION

In recent years field-scale experimental work on cocoa fermentations at the West African Cocoa Research Institute (W.A.C.

R.I.), and on the larger estates in New Guinea has revealed the possibility of modifying the traditional style of fermenting cocoa in two interesting ways (Allison and Rohan, 1958). Firstly, the investigations at W.A.C.R.I. have shown that Amelonado cocoa may be satisfactorily fermented in trays to a depth of four inches; no stirring is needed and the fermentation is said to be complete after three days. The trays are stacked one above the other and filled so that a small air space is left between each tray. The trays must also be protected from draughts. Small scale field experiments have been carried out at Naduruloulou to test this idea but the results are so far inconclusive.

The second of the proposed modified methods of fermenting cocoa is due to Bridgland of the Department of Agriculture, New Guinea (Harwood, 1957). The fresh seeds are put into a fermenting box in the usual way, but after 24 hours are taken out and spread over a clean floor where they remain for 20 hours; this period is known as the "resting phase". While on the floor the beans are turned frequently, after which they are transferred to the second fermenting box and treated in the normal way. The precise conditions under which the beans are "rested" are said to be important. Bridgland claims that his method is effective in reducing acidity and also any tendency to develop off-flavours.

Washing of Cocoa

Should fermented cocoa be washed or not? The biggest proportion of the world's cocoa comes from West Africa where the washing of cocoa is never practised. Urquhart (1955) does not even mention the subject in his book on cocoa. Yet in Western Samoa, which is relatively close to Fiji, washing plays an important part in the normal routine of cocoa preparation.

In the cocoa trade washed cocoa is not popular on account of the presence of beans with fragile and damaged or broken shells. Without an intact shell the bean is exposed to the troublesome attacks of the cocoa moth and other pests, resulting in losses in the cocoa store.

From the point of view of the producer the physical appearance of washed cocoa is superior to that of unwashed cocoa, and it is probably true to say that on this account it is easier for him to find a ready sale for the washed product. The keeping qualities, too, in a moist, hot climate are better in-so-far as risk of mould damage is concerned. It is also possible that washing reduces the acid content of fermented cocoa, although there is no real evidence in support of this surmise. The washing of cocoa has been tried at Naduruloulou but as far as one could tell no worthwhile advantage was gained by this treatment.

DRYING METHODS

Sundrying

Sundriers vary from simple mats laid on the ground or on raised tables to fairly elaborate systems incorporating trays mounted on rails and to combination hot-air sundriers fitted with sliding roofs. As far as cocoa preparation in Fiji is concerned, the sun is not going to play much part as a means of drying cocoa in areas where production is on an appreciable scale—the elements are far too unpredictable. But for the peasant farmer with a small number of trees sundrying may be the only practical solution; and so long as he is reasonably lucky with the weather he should succeed quite well. The beans need to be turned several times a day to prevent moulding and to obtain uniform drying. When mats are used, they should be rolled up and placed under cover at night and also during showery weather. Depending on the amount of sunshine and the prevalence of drying winds cocoa may be properly dried in 7 to 14 days.

Hot-air Drying

Hot-air driers are of two main kinds, the natural ventilation type and the mechanical, rotary type. For the small farmer and for co-operative organisations, the natural ventilation Samoan-type drier is recommended. Messrs. Cadbury Brothers Ltd., have printed an illustrated booklet (1957) describing the construction of this model and anyone desirous of building one should refer to the booklet for details.

Samoan Drier

This drier has been thoroughly tested under West African conditions and should prove of extreme value in Fiji. It is made largely of timber of local origin. The fire grate, flue and chimney are made out of oil

Photo—A.S.P. Pty. Ltd.

Plate 13. Sun drying cocoa in Papua-New Guinea

drums which are either welded end to end or are joined together by binding the ends with asbestos tape and aluminium strip and securing with stout wire loops. One model, with a drying platform 12 feet by 6 feet, may be seen at Naduruloulou: another model, at the time of writing, is under construction at Wailevu, Vanua Levu.

The 12 ft. by 6 ft. model has a capacity of 800–900 lb. of wet beans which are spread over the drying platform to a depth of two inches. Dry coconut husks or logs are burnt in the fire drum and the fire is regulated to give hot air temperatures not exceeding 180° F. beneath the drying platform. By maintaining a constant fire and by attending regularly to the raking of the wet beans, drying can be accomplished in 24–36 hours. In practice, it may be more convenient to allow the fire to die down at night, in which case the period of drying may have to be extended to 48 hours or longer. Some slight difficulty may be experienced at first with the regulation of temperature. For instance, the beans may dry more quickly at the fire-box end than at the smoke-stack end; this kind of anomaly can be overcome by re-arrangement of baffle plates over the hot end of the flue and by inserting the appropriate amount of heat-absorbing stones, iron plates, etc., into the cooler portions of the flue.

Although regular raking over of the wet or moist beans during drying is important it should not be overdone or the shells will become extremely brittle and liable to crack or split. Incidentally, the regular raking of the beans imparts a polished appearance to them which aids keeping qualities by suppressing superficial mould growth.

The cost of the Samoan-type drier erected at Naduruloulou was £200 complete with flue and stack of welded construction and with pandanus-covered roof. The larger model, with drying platform 24 ft. by 10 ft. would, of course, cost proportionately more; the output of this model is given as ½ ton per 36/48 hours.

For further details of the method of constructing the Samoan cocoa drier the reader should consult the booklet prepared by Messrs. Cadbury Bros. Ltd., (1957). Sectional views of this drier, reproduced from the above-mentioned booklet, are given in Figs. 5 and 6.

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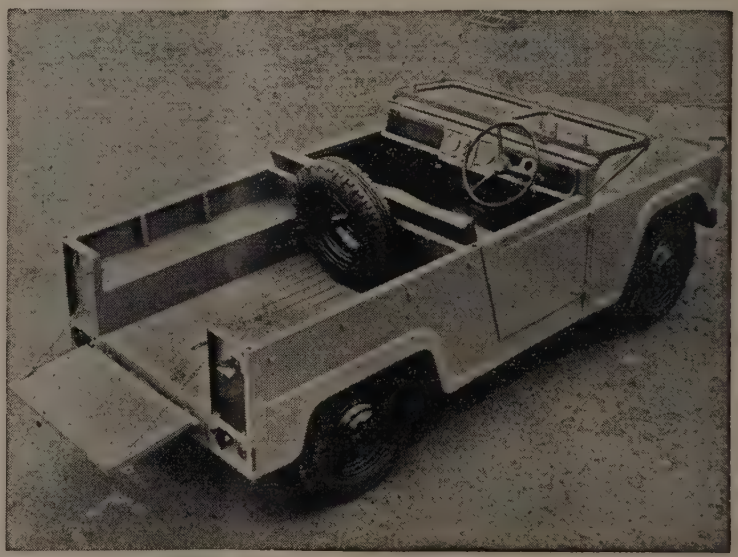

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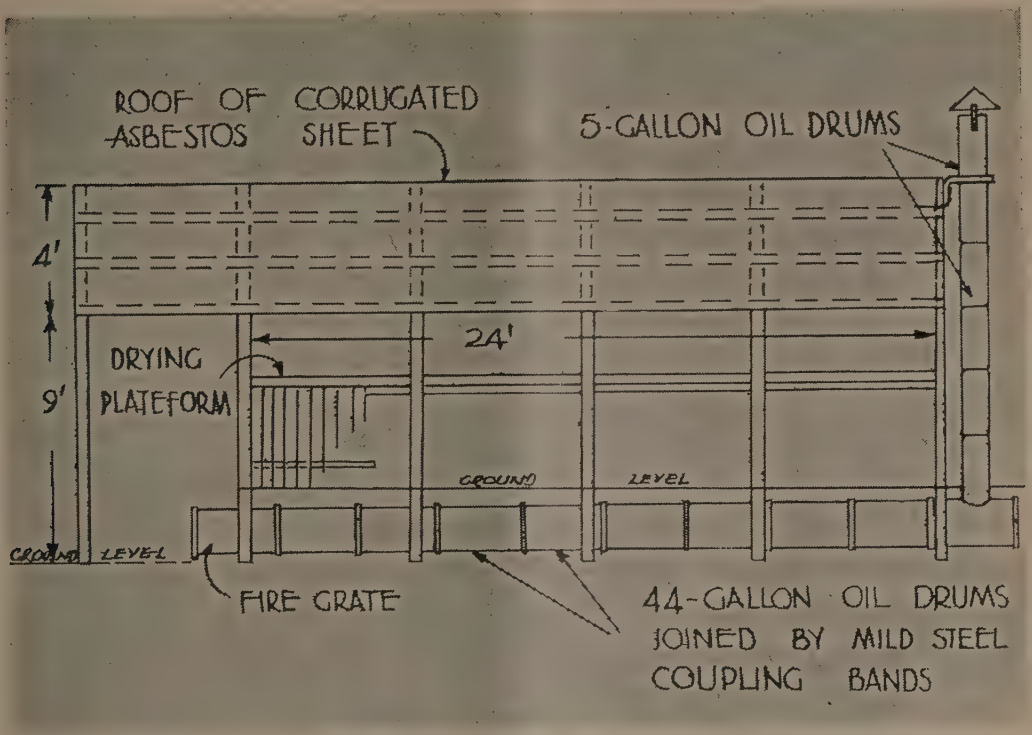

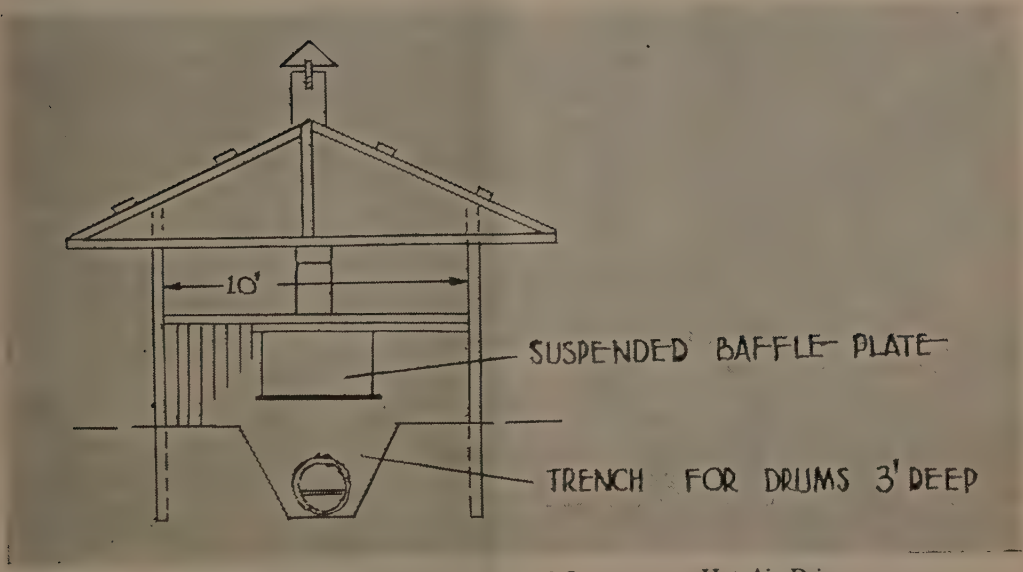

Figures 5 and 6. Sectional views of Samoan type Hot Air Drier

Plate 10. Drying platform of Samoan type drier, Naduruloulou *Photo—P.R.O.*

MARTIN DRIER

For even larger drying capacities the Martin type of drier, in use on the West Samoan Trust Estates and on the larger estates in New Guinea, is recommended. This drier has a drying platform of 45 feet by 25 feet and can take up to 5 tons of wet beans at one loading.

MCKINNON ROTARY DRIERS

In Western Samoa and New Guinea the McKinnon rotary drier has long been regarded as an important accessory in large-scale cocoa-drying undertakings. Its main function is usually to " finish off " the drying process after the cocoa has received a limited period of drying in a hot-air drier of the natural ventilation type. Not only are the beans thoroughly dried in this way but an attractive polished appearance or lustre is imparted to them and, furthermore, much unwanted volatile acidity is taken out of them. This last-mentioned feature is important where there is a tendency for the beans to retain high acidity when dried in the ordinary way.

It is not possible to dry wet cocoa—taken straight out of the fermentary—in an unmodified McKinnon drier, since the perforations in the walls of the drum quickly clog up with pulp residues from the wet beans; this slows down the rate of drying and adds to the difficulties of cleaning the inside of the drum after use.

There are five sizes of machine available, with capacities ranging from 1,700 lb. to 7,000 lb. of moist beans. Oil can be used as an alternative to solid fuels for the heating unit. Present-day prices (1959) for machines fitted with oil burning equipment range from approximately £830 for the 4 ft x 3 ft model to £910 for the 5 ft x 3 ft model, c.i.f. Suva.

Plate 11. Samoan type Drier, Naduruloulou, showing Fermentation Boxes in background

Photo—P.R.O.

STORAGE OF COCOA

The storage of cocoa should present little difficulty provided strict attention is given to the maintenance of dry conditions and absolute cleanliness in the storeroom. The storeroom should also be kept as cool as possible and it should be well ventilated. The bags should not be allowed to rest on a concrete floor inside the store but should be raised a few inches above it by means of wooden racks.

There are special precautions to take before bagging cocoa. Firstly, beans should not be left exposed to insect attack, or considerable damage may be caused by the cocoa moth and other pests. These insects lay their eggs in beans whose shells have been broken during processing or penetrated by the germ tube during germination. Later, after the cocoa has been transferred to the store, the larvae hatch out and spread the damage to other beans. Secondly, the moisture content of the beans should be carefully checked before bagging. If it is over 8 per cent it is too high; at 7 per cent or below the cocoa will store in bags perfectly well without risk of spoilage by moulds.

After bagging, insects may be kept away by spraying the walls of the storeroom with a 5 per cent D.D.T. solution four times a year.

New jute bags should always be used for storing cocoa and a close weave should be chosen so as to exclude insects as far as possible.

OTHER ASPECTS OF COCOA QUALITY

The main value of cocoa lies in its cocoa butter content and in the chocolate flavour that is produced by roasting the beans. The strength of this chocolate flavour is a vital factor in determining the use that is to be made of the cocoa. For example, a strong flavour of chocolate such as is obtainable from Amelonado cocoa is admirably suited for milk chocolate manufacture. Cocoa which is characterized by a mild chocolate flavour is, on the other hand, more suited to the manufacture of plain chocolate moulded bars where high quality is desired. The latter kind of cocoa is the one with which we are most familiar in the South Pacific. Not only is the flavour of this cocoa mild in character but it is frequently associated with ancillary flavours reminiscent of raisins, caramel or liquorice. However, since the emphasis in the demand for cocoa today lies in the direction of strong chocolate flavours, the Fiji Department of Agriculture has thought it advisable to introduce new types of cocoa into Fiji and to breed improved types from local material which will tend to give added strength of chocolate flavour to our cocoa in years to come. At the same time, the cocoa known to be synonymous with weak or poor chocolate flavours will gradually be replaced by better types.

Two other important factors concerning cocoa quality are shell content and size of bean.

Shell Content

The shell serves a most useful purpose in its protective role against insects and dirt, but once it has been separated from the nibs it is virtually waste material.

The usual aim of the cocoa buyer is therefore to select good quality beans with as low a content of shell as possible. The shell content of cocoa produced by a wide range of existing trees in Fiji has been shown to lie between 8 and 18 per cent, while bulk field-scale fermentations have given beans with an average value of 12 per cent; this figure is near the upper limit generally accepted by the trade.

Bean Size

The minimum weight of bean which the chocolate maker normally accepts is 1 gram. Below this limit technical difficulties arise in the factory with the adjustment of the rollers designed to break the roasted beans; moreover, a small bean usually means a high percentage of shell. Bean size is therefore an important factor in cocoa production.

All undersized and shrivelled beans should be removed before cocoa is marketed—an operation normally performed during grading. As a matter of interest, a recent check with bulk fermented beans at Naduruloulou showed that shrivelled and undersized beans accounted for 4 to 5 per cent of the total weight.

FERMENTATION DEFECTS

Under-fermentation and over-fermentation are defects for which the cocoa buyer is on the constant lookout. Under-fermentation is easily detected from a visual examination of the internal parts of the beans, colour and texture being the guiding features. Chocolate made from under-fermented cocoa has a rather unpleasant bitter and astringent taste.

Over-fermentation is less easily detected and gives rise to weak or poor chocolate flavours. It is a serious fault of cocoa because the chocolate technologist has, up to the present time, failed to find any means of recovering the lost flavour. This type of cocoa is consequently only of real value as a source of cocoa butter.

Reference has already been made to the undesirability of foreign flavours and off-flavours and it will suffice here to add a note of advice to the would-be producer to take every care possible during cocoa preparation to avoid these troubles. This may be done by observing strict cleanliness in and around the fermentary, by maintaining correct fermentation temperatures and aeration, by preventing mould growth during drying, and so on.

ECONOMIC VALUE OF COCOA

Cocoa serves mankind in three important ways. It can be made into eating chocolate, drinking cocoa or a chocolate flavouring material suitable for a host of popular foods and drinks. Cocoa is also the commercial source of cocoa butter and theobromine.

CHOCOLATE

In its simplest form, chocolate consists of a mixture of crushed and finely-ground roasted cocoa nib, cocoa butter, sugar and flavourings, which have undergone special processing. An important by-product of chocolate making is cocoa powder, and, in fact, it is so important that the output of chocolate is controlled by the sales of cocoa powder. Cocoa powder is the residue left after extracting cocoa butter from finely ground, roasted cocoa nib. The residue provides the material for drinking cocoa and cocoa flavourings.

Milk chocolate is by far the most popular form of eating chocolate in the consuming countries. From a technical point of view milk chocolate is interesting because there is competition between two flavours, and in order that the flavour of the milk shall not unduly mask the flavour of the chocolate, the latter needs to be strong. Hence the heavy demand for Amelonado cocoa and the lesser demand for hybrid or flavour cocoas.

COCOA BUTTER

Cocoa butter is exported from some of the cocoa producing countries, including Ghana and Brazil. Presumably the lowest grades of cocoa are used for this purpose and the industry must serve as an important outlet for cocoa not suitable for chocolate manufacture. In addition to being a principal ingredient of chocolate, cocoa butter has important uses in the cosmetic and pharmaceutical industries.

THEOBROMINE

Theobromine is present in cocoa beans to the extent of 1 or 2 per cent and has mild stimulating properties; it is closely related to the alkaloid caffeine, the stimulant present in tea and coffee.

Commercially, theobromine is obtained by a process of extraction from the waste shell produced by chocolate factories. It is on account of the presence of theobromine that cocoa shell is found unsuitable as a cattle or poultry feed, except in restricted amounts.

LOCAL COCOA DRINKS

In Western Samoa the indigenous people take advantage of the local supply of cocoa to prepare a crude but refreshing type of cocoa drink for themselves. This "home-made" beverage is inclined to be somewhat rich in composition because it contains all the natural fat of the bean—unlike the preparation made with bought cocoa powder which has had most of the fat extracted from it. However, it makes a satisfying drink and has the important advantages of cheapness and availability.

To prepare this drink the beans (previously fermented and dried) are roasted over hot stones; the shells are then removed and the nibs are pounded into a coarse

powder. Hot water is poured over the powder, and sugar is added to taste. Milk may be added when available to improve the flavour.

The Samoan practice of making domestic use of locally produced cocoa was established in the island of Gau in the Fiji Group some years ago, and it is to be hoped that this knowledge will soon spread to other parts of Fiji when new plantings come into bearing.

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Plate 12. The " Sterling " Cocoa Drier. Block by courtesy of Wm. McKinnon Co., Ltd.

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INSECT PESTS OF COCOA

BY B. A. O'CONNOR

As the growing of cocoa on a commercial scale is a new venture in Fiji, it is to be expected that new pests of the crop will appear as time goes on. This has been the experience in other countries, where it has been found that native insects, such as bugs of the family *Miridae*, gradually became adapted to feeding on cocoa plants. The pests of cocoa in Fiji have not been the subject of special study, except in the case of the Rose Beetle, which was investigated by J. S. Pillai, formerly Entomologist in the Department of Agriculture. The known insect pests are dealt with below:—

PESTS OF THE GROWING TREE

THE ROSE BEETLE, *Adoretus versutus* Har. Lever, R. J. A. W. (1945), Pillai, J. S. (1956–57)

This is a brown " chafer " beetle, about 7/16 in. long and 3/16 in. wide. Eggs are laid in small clusters in humified soil, and the larvae feed on decaying vegetable matter, pupating several inches below the surface. There are no precise figures regarding duration of the various stages of the life-cycle, different investigators having obtained varying results. Roughly, the incubation period of the eggs appears to be from one to two weeks, the larval stages occupy several months, and the pupal stage 10 days to a fortnight. The adults live for five or six weeks.

Only the adults cause damage to plants. They are nocturnal and feed on the leaves of a wide range of host-plants, chewing holes right through the leaves. Where infestation is severe on a young plant, most of the green tissue of the leaves is destroyed. Large numbers of beetles are on the wing from about mid-December to mid-May; during the remainder of the year they are less numerous. The beetles are attracted to light, and may often be found near lights at night; during the day they shelter in the soil. Both adults and grubs seem to concentrate under mulch or leaf-litter.

Indications are that damage to plants in a cocoa grove is caused primarily by beetles which remain in the grove, not by immigrants from surrounding areas. This simplifies control measures. Cocoa is most susceptible to serious damage up to the age of 18 months. The young plants may lose a high proportion of their leaf-area and may even be killed. After the age of about five years the plants are not severely damaged.

Control—Field experiments carried out by Pillai suggested that the presence or absence of shade has no influence on damage done by *Adoretus*. On the other hand, the erection of barriers round young plants, the barriers being slightly higher than the plants, gave complete protection. In this case the barriers consisted of plastic gauze held in place by sticks planted in the ground. In Samoa, barriers made of various materials are erected around young plants and are said to give good protection. The cost of labour for this operation is, of course, considerable.

Pillai also conducted an uncompleted series of experiments on field control of the Rose Beetle, using Dieldrin. These gave promising results but further work is necessary. Tentatively it is recommended that, for the protection of young plants, 3–6 pints of Dieldrin 15 per cent Emulsifiable Concentrate be applied per acre. The concentrate should be mixed with sufficient water to permit spraying of the plants and the surface of the soil, especially where mulch or litter is lying. It may be that spraying with a mist-blower would also be successful. A trial with a machine giving a coarse mist, using $2\frac{2}{3}$ pints of Dieldrin 15 per cent Emulsifiable Concentrate in $6\frac{2}{3}$ pints of water per acre, gave good results. It appears that treatment with Dieldrin can protect young plants from damage for a period of several months. Where a single annual treatment is contemplated, the appropriate time to apply

it would be in the latter half of December, when heavy flights of the beetle usually begin.

Caterpillar Pests—The large caterpillars of two species of moths frequently cause severe damage to young seedlings in the nursery. These species are *Prodenia litura* F. and *Plusia chalcites* Esp., both kinds of caterpillars feeding on the young leaves and generally hiding in the soil at the base of the plant during the day. The caterpillar of *Prodenia* is dark brown, with black, triangular markings behind the head, while that of *Plusia* is light-green and loops its body when moving. They may be controlled by spraying the foliage with D.D.T. (formula No. 5) or Dieldrin (formula No. 2).

Adoxophyes fasciculana Wlk. is a moth whose small caterpillars roll the leaves of cocoa and then feed inside the rolled leaves. The damage done is normally not sufficiently serious to warrant treatment, but D.D.T. sprays probably control them.

APHIDS, MEALYBUGS AND ANTS

The Aphid, *Toxoptera aurantii* Boy. de Fonsc., and the mealybug, *Planococcus citri* Risso, may occur in large numbers on cocoa plants and are fostered by ants which will often construct protective coverings for the mealybugs. So far, we know of no diseases of cocoa which are transmitted by mealybugs in Fiji, and stringent quarantine regulations are in force to prevent the introduction of diseases from overseas.

Aphids are found on the flowers and young shoots. It seems possible that they could damage the flowers and perhaps reduce the crop, but we do not know if this is the case. Mealybugs occur on the flowers and pods, and in their case also there is no information on the nature and extent of damage done. Pillai (1956–57) found that when *Planococcus citri* was confined on young pods in plastic bags some spotting of the pod occurred, but no significant kill of aphids, mealybugs and ants could be obtained by spraying with Diazinon Emulsifiable Concentrate (formula No. 1). Treatment of the trunks of trees with Dieldrin (formula No. 3) gives good control of ants, with consequent heavy mortality of mealybugs.

BORING BEETLES

Beetles of the families *Bostrychidae* and *Scolytides* have occasionally been recorded as boring in the stem and branches of cocoa trees, but they are not at present pests of any importance and control measures have been unnecessary. These beetles often attack dead or dying wood, but on occasions similar species have caused serious damage to cedar and mahogany seedlings in nurseries of the Forestry Department. These attacks have been well controlled by spraying with B.H.C. (formula No. 4). There are as yet no records of attack on cocoa by *Longicorn* beetles.

There have been instances of surface lesions on pods in the form of large black spots of dead tissue. The damage is superficial and not commonly encountered, but somewhat resembles that of *Capsid* bugs in other countries; the cause is not known. A *Coreid* bug, *Brachylybas variegatus* Le Quill., has been found on young pods, but has not been incriminated as causing noticeable damage.

PESTS OF STORED BEANS

As there has as yet been no commercial production of cocoa in Fiji, we have no experience of the pests of stored beans. However, there are several insect pests of stored products in Fiji which are known to attack cocoa beans in overseas countries. It appears that the Fig Moth, *Ephestia cautella* Walk., and the Cigarette Beetle, *Lasioderma serricorne* F., are the most serious pests and both of these occur in Fiji.

Prevention of insect attack on cocoa beans is largely a matter of sanitation. The following points are of importance:—

(*a*) Beans must be fully fermented and properly dried, as partly-fermented and damp beans may be heavily attacked by insects.

(*b*) The beans must be placed in bags which are new, or which have been fumigated or treated with insecticide. Old, untreated bags may carry large numbers of insect pests.

(*c*) Bagged beans must be removed to a proper store as soon as possible.

(*d*) The store should be dry and airy and constructed in such a way that it has a minimum of cracks and crevices which can shelter insects. It should be so built that it can easily be made airtight for fumigation purposes.

(*e*) If possible, only cocoa should be kept in the store, otherwise there is a risk of infestation from other products such as copra, rice, maize, flour, peanuts, etc.

(*f*) The store should be kept clean, walls and floors being regularly cleaned to remove insects and debris.

(*g*) The inside surfaces and floor of the store should receive regular 3-monthly treatments with a residual spray of D.D.T. wettable powder (Formula No. 6).

SPRAY FORMULAE

1. *Diazinon* for control of ants and mealybugs—Mix one fluid ounce of 20 per cent Emulsifiable Concentrate with 10 pints of water. It is possible that a good kill of mealybugs could be obtained at a much lower concentration (e.g. one fluid ounce of Emulsifiable Concentrate in 6 gallons of water) but field trials at lower strengths have not yet been made.
2. *Dieldrin* as a soil spray for cutworms attacking seedlings or a foliage spray for ants. Mix one fluid ounce of 15 per cent Emulsifiable Concentrate with one gallon of water.
3. *Dieldrin* as a trunk treatment for ants. Mix one fluid ounce of 15 per cent Emulsifiable Concentrate in one pint of water, *or* use a dieldrin lacquer.
4. B.H.C. as a treatment for branches attacked by boring beetles. Mix 1 lb. of 50 per cent Dispersible Powder with one gallon of water.
5. D.D.T. as a soil spray for cutworms or a foliage spray for leaf rollers. Mix one ounce of 50 per cent Dispersible Powder with 3 gallons of water.
6. D.D.T. as a residual spray for storage buildings. Mix 1 lb. of 50 per cent Dispersible Powder with one gallon of water.

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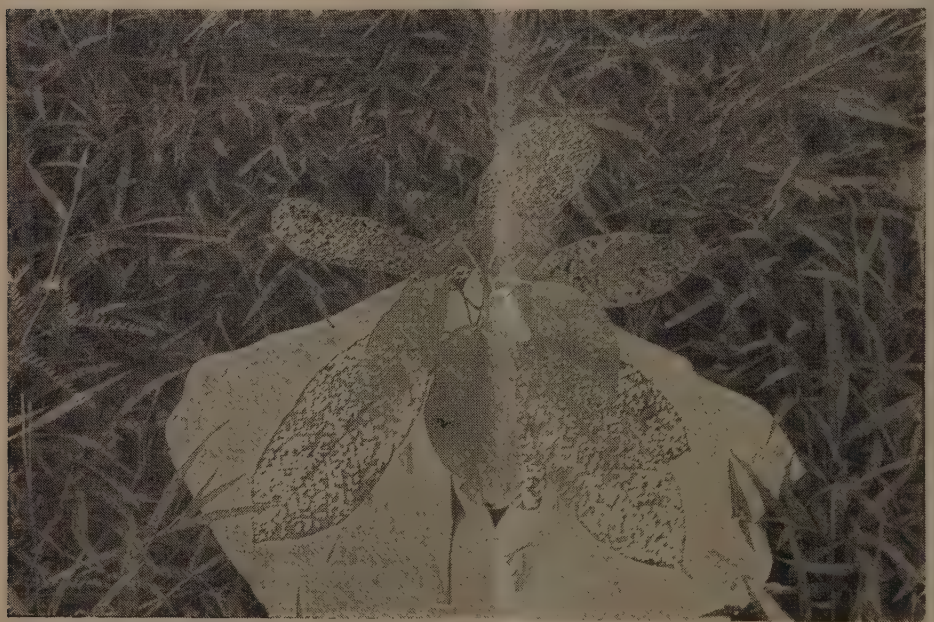

Plate 14. Young cocoa plant showing Rose Beetle damage *Photo—B. A. O'Connor*

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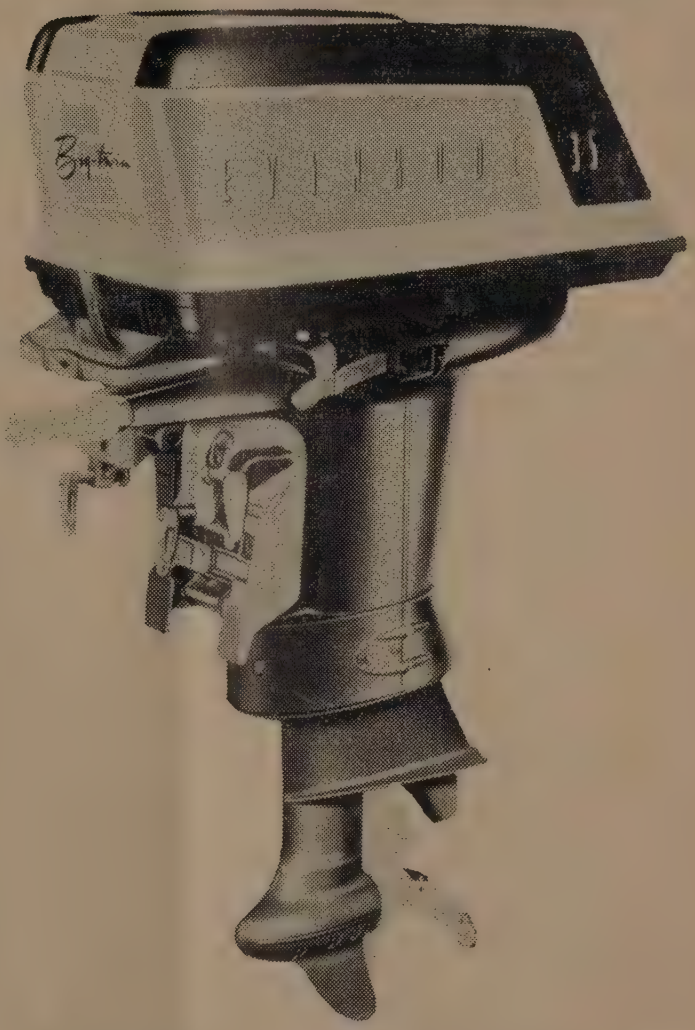

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DISEASES OF COCOA

BY L. W. HARWOOD

Fiji is very fortunate in that the serious diseases which attack cocoa in places such as West Africa, the West Indies and the mainland of South America have not yet been recorded in the Colony.

Morwood (1956) has recorded the following preliminary list of diseases of cocoa in Fiji:—

Pathogen	*Common Name*
Botryodiplodia theobromae Pat. ..	Pod Rot
Corticium salmonicolor B & Br. ..	Pink Disease
Fomes noxious Cornu	Root Disease
Marasmius scandens Mass	Thread Blight
Phytophthora palmivora Butler ..	Black Pod
Txyridaria tarda Bancroft	.....

BLACK POD

The most important of the local diseases is Black Pod, *Phytophthora palmivora.* The fungus attacks cocoa wherever the crop is grown and, in the aggregate, probably does more damage as a pod-rotting fungus than any other; pods of all ages are attacked.

The attack generally commences at some point where water can collect, e.g. around the pedicel insertion, at the base of the pod, or where two pods touch. Wounds are not necessary for the entry of the fungus. The appearance of the disease is indicated by a brown spot on the pod wall; the spot appears about five days after infection and rapidly enlarges until the whole pod is invaded and blackened. If the attack takes place at a late stage of pod development only the pod itself may be damaged, the beans being brown but saleable. Attack in the early stages of pod development may result in complete destruction of the pod. In heavy rainfall areas, 30–60 per cent of the pods may be infected. Losses can be particularly heavy in wet " dry " seasons.

Absolute control is very difficult. Spraying with copper fungicides is recommended in some countries and may be feasible when the incidence of this disease is high. Best results have been achieved in Fiji by the removal of the infected pods and reduction of shade, especially when out-breaks are severe.

Removal of diseased pods is important as failure to do this may result in the production of cankers. These cankers are caused by the same organism and show themselves as patches of dead wood exuding a reddish liquid. The chief source of infection is from " black pods " infected by the fungus which in turn infects the flowering cushions. Control of canker on a full scale is difficult and expensive. Badly cankered trees should be replaced.

Cherelle Wilt, which is a physiological condition confined to pods 6–8 weeks old, is often mistaken for Black Pod. The difference between Cherelle Wilt and Black Pod may be seen by cutting through the pods—Smith, Harvey C. (1954). If the pods have not been dead for more than about three weeks those killed by Cherelle Wilt will be green, yellow, or light brown inside whilst victims of Black Pod will be completely blackened.

POD ROT

Botryodiplodia theobromae, S.P.C. list (1952), or *Diplodia theobromae* is a secondary fungus found in all cocoa growing countries. Diplodia Pod Rot, which is caused by this fungus, is not a serious disease as it only attacks damaged pods, following on damage by rats, parrots, etc., or damage in harvesting. There is no worthwhile control.

The fungus also causes Diplodia Dieback which is a debility disease of cocoa and other tropical plants. The disease may be recognized by the drying out of the branches and dieback from the tips backwards, the branches later turning black. Factors conducive to this disease include insect attack. poor drainage, and lack of pruning.

Botryodiplodia theobromae has also been recorded in Fiji by Morwood (1956) as a root disease attacking damaged and debilitated trees.

ROOT DISEASES

Two other root diseases, *Fomes noxious,* Parham, B. E. V. (1952) and *Ustilina deusta,* Parham, loc. cit., have been found in Fiji. Neither of these has, as yet, assumed serious proportions.

Fomes noxious is usually serious in recently cleared plantations of young trees. It is easily recognized by its rhizomorphs which are white or yellowish, stout, smooth cords about ¼ inch thick. These are firmly attached to the roots and may spread out into a sheet of mycelium which penetrates the roots causing decay.

The disease may be controlled by regular inspection of young trees and removal of diseased tissue by tree surgery.

Ustilina deusta generally appears in old trees as a Collar Rot, causing a dry rot with black lines running irregularly in the tissue. The fungus, like *Fomes noxious*, spreads by root contact and requires a wound for entry. The progress of the disease is slow. Control is by tree surgery, removal of invaded parts and painting of damaged tissue with Bordeaux Paste.

Both *Fomes noxious* and *Ustilina deusta* grow over a wide range of conditions. They are dangerous parasites which cannot be fully controlled by cultural practices. Their spread, which is by root contact and infected material, is slow and sure. They are best controlled, as are the majority of similar diseases, by the eradication of infected material and the source of infection.

PINK DISEASE

The disease is caused by the fungus *Corticium salmonicolor*, Knowles, C. H. (1916) and is relatively unimportant. The fungus attacks cocoa growing under very wet conditions. The twigs and branches become covered with a white mycelium which later turns pink and on which the spores are formed. This may be followed by defoliation and death, although this rarely extends beyond the death of a few branches.

Urquhart (1955) records the fungus as being present in South America, the West Indies, the Cameroons and New Guinea. Experience in New Guinea has shown that the fungus is associated with Pigeon Pea, *Cajanus cajan*, which is often used as a temporary shade for cocoa.

The disease is more serious in badly drained areas, so improvement of drainage should reduce its incidence. Control is usually effected by the removal of infected parts and lowering the humidity by reducing the amount of shade and by pruning.

DANGEROUS DISEASES NOT RECORDED IN FIJI

The future of Fiji's cocoa industry depends very materially on keeping out the dangerous diseases which cause heavy losses in well established cocoa-growing countries. The need for control of introductions and proper quarantine is therefore vital. The fungus disease Witches' Broom, *Marasmius perniciosus*, which is a serious problem on the mainland of South America and in parts of the West Indies, could create havoc if inadvertently introduced to Fiji. So, too, could Monilia Pod Rot, *Monilia roreri*, which is confined to the South American continent.

Swollen Shoot, which is a complex of virus diseases, is a major problem in West Africa. In Trinidad, two or more strains of a virus, similar to milder West African strains, occur. Varieties of cocoa resistant to these viruses are as yet unknown. The vectors are various species of mealybugs, the most important of which, in West Africa, is *Planococcoides njalensis* (*Pseudococcus njalensis*), fortunately not present in Fiji. However, the mealybugs *Pseudococcus citri*, *Dysmicoccus brevipes* and *Ferrisia virgata*, which are vectors of the milder strain which occurs in Trinidad, are present in the Colony and could transmit the disease if infected material were inadvertently introduced.

Witches' Broom, Monilia Pod Rot, and Swollen Shoot are most dangerous diseases of cocoa and losses from these diseases can assume terrific proportions. At the 1953 Cocoa Conference, S. L. Hale estimated that the annual cocoa losses due to Swollen Shoot and Witches' Broom and other diseases (excluding Black Pod) totalled 50,000 and 20,000 tons respectively.

The Department of Agriculture is taking every precaution to ensure that these dangerous diseases are not introduced into Fiji.

The policy is that planting material of plants which are of actual or potential economic importance to Fiji will normally,

with a few listed exceptions, be introduced solely by the Director of Agriculture. No planting material of cocoa (including seed) may be imported from any country where specified diseases occur or are suspected to occur, unless such plants have been grown in quarantine at the Royal Botanic Gardens, Kew, and are certified by the Director of the Royal Botanic Gardens to be free from such diseases; these are:—

Swollen Shoot Virus Disease,
Witches' Broom Disease (*Marasmius perniciosus*),
Other Virus Diseases, and
Monilia Pod Rot (*Monilia Roreri*).

Rigorous control over introductions and efficient quarantine should ensure that Fiji's new and promising industry is not endangered by the introduction of dangerous diseases.

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NOTES ON COCOA NUTRITION

BY J. W. McPAUL

In summing up the 1957 Cocoa Conference in London Mr. Paul Cadbury said this of fertilizers:—

" It is quite clear that at this moment not enough is known of the problem for specific advice to be given to the grower. Very nearly every other crop in the world depends to some extent on the use of fertilizers and this is clearly a subject which will have to receive a good deal of attention."

To quote yet another authority, the late C. F. Charter (1957) said:—

" Manuring with suitable fertilizer to improve the base status and raise the reaction of the acid soils would, if properly carried out, result in greatly increased yields and permit many areas not now capable of supporting cocoa to produce profitably. Of this I believe there should be no doubt whatsoever."

Cocoa is a tree crop which can go on producing throughout a man's lifetime. It takes several years to come into bearing and every effort must be made to ensure that it becomes economically productive as soon as possible. Further, it must be kept productive. This will be dependent on many interrelated factors, including selection of suitable soil, sound agronomic practices and maintenance of soil fertility.

NATURAL CONDITIONS

It is known that cocoa grows best under conditions similar to those of its natural habitat, which is as part of the undergrowth in the tropical rain-forests of South America. It is therefore important to understand the conditions under which cocoa grows in this environment a d how soil fertility is maintained.

In its natural conditions cocoa is always shaded by the larger trees. While some countries endeavour to dispense with shade for cocoa, it is considered essential in Fiji.

Temperature and humidity, together with the moisture content of the soil, are much more uniform in a tropical rain-forest since there is an absence of direct sunlight and drying winds; the soil is also covered with a layer of organic matter in the form of leaf mould. This is beneficial to soil structure as it retains moisture, makes the soil more able to hold nutrients and is a valuable source of plant food. Another important function of organic matter is that it provides an ideal growing medium for certain soil micro-organisms. Cocoa, as well as most tropical forest trees, is considered to benefit from association with these organisms as the fungi and bacteria obtain certain of their nutrients from the plant roots and, in return, assist the roots to perform their essential functions.

The continuous supply of leaf mould is one of Nature's ways of keeping a soil fertile. In the absence of this supply soil fertility rapidly deteriorates in a tropical climate. The reason is that in a hot, wet climate rock minerals, which are the original source of all the mineral foods of plants, are rapidly decomposed and, as the nutrients are released, they are subject to leaching by heavy rains. Forest trees, which have deep, extensive roots, are able to offset this loss. They absorb the minerals as they are released and can also retrive those which are too deep down in the soil for the smaller plants; these minerals are then transported to the leaves. When the leaves are shed and decompose the absorbed nutrients are again released into the surface soil and again become available to the trees, thus maintaining a " nutrient cycle ". Such a cycle, however, is not able to provide nutrients which are originally absent from the soil and it is here that artificial fertilizers are necessary.

Photo—P.R.O.

Plate 15. Plant from rooted cutting, 2½ years old ; note low branching habit

INVESTIGATIONS OF COCOA FERTILITY

In Fiji, there are differences of climate, soils and farming practices as compared with overseas cocoa producing areas and it cannot be assumed that overseas practices would be entirely suitable to Fiji. It is therefore necessary for investigations to be carried out under Fiji conditions.

There are several methods of setting about the investigation of cocoa nutrition. These include soil analyses, field trials, leaf injections, pot trials, leaf analyses and the study of leaf symptoms and are discussed in the following paragraphs:—

SOIL ANALYSES

Much work has been done on the chemical analysis of cocoa soils. This work, when correlated with productivity and health of the cocoa, provides a valuable indication of the fertility requirements of the crop. One disadvantage of this approach is that, although a soil contains a certain level of a particular plant nutrient, it does not always follow that the nutrient is present in a form available to the plant.

SOIL ACIDITY

This can be readily determined and is probably the most important single soil determination.

Cocoa thrives best in a neutral or slightly acid soil; since most of the soils in South Eastern Viti Levu are markedly acid the use of lime to neutralize excess acidity may be an advantage.

NITROGEN AND ORGANIC MATTER

The vegetative growth of plants depends on an adequate supply of nitrogen. With cocoa, the response to nitrogen is increased as the tree becomes more exposed to sunlight, Murray, D. B. (1953) and inadequately shaded cocoa will require a greater supply of nitrogen. Under natural conditions cocoa obtains much of its nitrogen from the decomposition of organic matter, hence the importance of mulching for cultivated cocoa. It is the practice in overseas cocoa areas to put farmyard manure or compost into the planting holes and to maintain a good surface mulch under the trees.

Organic mulches and manures are important in the following respects:—

(1) They are a source of most plant foods, particularly nitrogen. They must, of course, decompose before these nutrients are released; decomposition is relatively slow and consequently a continuous supply of food is available until decomposition is complete.

(2) They have a high capacity for retaining plant nutrients against leaching.

(3) They have a beneficial effect on the physical properties of the soil and give the soil higher water-holding capacity with better internal drainage.

(4) As organic matter decomposes various acids are formed which in turn break down rock minerals, thus releasing plant food; these acids also help to neutralize soils which are alkaline.

(5) They maintain soil moisture and retard evaporation—a most important function during the drier months. Mulches also suppress weed growth.

(6) Mulches act as a protective layer over the surface feeding roots and thus minimise the risk of injuring them with weeding implements.

A chemical measurement which is considered of fundamental importance in cocoa nutrition is the "C/N Ratio", a measurement of the proportion of carbon to nitrogen in the soil. As a generalization, undecomposed organic matter contains fifty times as much carbon as nitrogen, i.e. it has a C/N Ratio of 50. As decomposition takes place by the action of soil micro-organisms, much of the carbon is released as carbon dioxide gas while some of the carbon and most of the nitrogen is absorbed by fungi and bacteria. Consequently, the C/N Ratio becomes smaller until a stage is reached where the rate of decomposition is balanced by the rate of replenishment of organic matter. The C/N Ratio of a good cocoa soil should not be less than 10.

One of the practical considerations regarding the effect of mulches and organic manures on cocoa is that a source of nutrients in an available form is assured, providing vegetative material used as mulch

has been obtained from a fertile soil. If cocoa is growing on a soil deficient in, say, magnesium, it is most unlikely that the cocoa would receive an adequate supply of this element when vegetation grown on the same soil is used as mulch. There is consequently good reason for endeavouring to bring in additional organic material from an outside source. In this connection A. Jacob and H. von Uxekull (1958) suggest that artificial fertilizers might be more effective in cocoa culture when used for the production of a grass for mulching.

Nitrogen can also be supplied by the use of artificial fertilizers such as urea or ammonium sulphate. The latter tends to make soils more acid and its continued use would not be advocated on acid soils. These nitrogenous fertilizers are very soluble, and, since cocoa grows in the higher rainfall areas, regular applications are necessary to replace loss caused by rain.

PHOSPHATE AND POTASH

The soils of Fiji are generally very low in available phosphate; there is, however, a high amount of *total phosphate* which is chemically bound-up with aluminium and iron in an unavailable or " fixed " form; it follows that any artificial phosphatic fertilizer, such as superphosphate, which is applied to a soil will eventually be " fixed ". In an attempt to slow down the rate of fixation, various methods of applying phosphates, such as fertilizer placement, have been tried but the labour involved is expensive. Broadcasting superphosphate around the plants, either directly to the soil or to the mulch, thus producing a " fortified mulch ", is probably the most economic method of application.

Amongst its other functions, phosphate is important in root development and for the growth of soil micro-organisms.

A special role of potassium, generally referred to as potash, is that it helps the cocoa plant to make most use of the limited sunlight it receives. If the tree is given more light its potassium requirement is reduced but it then needs more nitrogen. Potash is present in fair quantity in Fiji soils but only the results of experimental work will determine if there is an adequate supply for cocoa.

LIME AND MAGNESIUM

When lime is applied to an acid soil it neutralizes the acidity and thus conditions are made more favourable for the release of the majority of plant nutrients. Lime cannot, of course, release nutrients which are not already present in the soil but can only facilitate the availability of those which are present. For example, phosphate becomes " fixed " or chemically bound with aluminium and iron under acid soil conditions; the application of lime helps to overcome this problem of fixation.

On the other hand, it is detrimental for a soil to contain too much free lime, either by over-liming or in the form of naturally-occurring lime. Such a condition is difficult to remedy. The application of sulphur or ammonium sulphate will help to correct an alkaline soil but it can be a costly procedure. An alkaline soil frequently has deficiencies such as iron, manganese and zinc. However, Harvord (1954) has shown that cocoa can tolerate quite a high soil content of calcium in the presence of adequate organic matter.

Another important role of lime in the soil is to supply calcium, which is essential to cocoa. Many acid soils in South-Eastern Viti Levu may well respond to applications of lime, both for the correction of excess acidity and to ensure an adequate supply of calcium for the plants.

TRACE ELEMENTS

These are chemical elements required by both animal and plant life in very small quantities. The best known are boron, zinc, iron, manganese, molybdenum, copper and cobalt. The role they play in plant nutrition is complex and not fully understood; however, it is probable that the growth of cocoa on some acid soils in Fiji could be restricted because of trace element deficiencies; this can only be verified by investigation. Once the deficiencies are found, they are generally easily remedied on acid soils.

Here is yet another important role for organic matter in that it can remedy or prevent these deficiencies as it contains a supply of trace elements. This is also one of the reasons why blood-and-bone fertilizer is beneficial.

However, in plant nutrition locally, the first emphasis should be on basal fertilizers such as superphosphate, potash and urea.

FIELD TRIALS

These are the most practical methods of demonstrating the effect of fertilizers. However, the responses from cocoa are not always as obvious and rapid as those obtained from other crops growing on nutritient deficient soils and it may be several years before the results of field trials can be applied to produce any overall increase in crop yields.

To carry out a field trial, it is necessary to select an area of soil which is as uniform as possible. Plots consisting of equal numbers of cocoa trees are then given different fertilizers. The yields from these plots are recorded and by this method it is possible to determine which treatment is the best for the soil type.

As there is such a wide range of soil types and of fertilizers, the latter including trace elements, it requires a large number of field trials to find the answers. This is why soil and leaf analyses, pot trials and leaf tests are valuable because they serve to indicate possible deficiencies more rapidly.

LEAF SYMPTOMS

The experienced observer can often tell which nutrient is most deficient in a plant by observing various irregularities in the colour and growth of the leaves. For instance, a leaf which is a very light green colour could indicate a lack of nitrogen; similarly, a leaf which dies around the edges could indicate a potassium deficiency.

LEAF ANALYSES

By comparing the chemical analysis of an unthrifty plant with that of a healthy plant it is possible to determine what nutrients are present in sub-normal amounts. With sugar cane, for instance, it is possible to correlate the levels of the various nutrients present in the leaf with the expectation of a certain yield; within limits, the amount of fertilizer to be added to the soil can then be recommended, though allowances must be made for climatic and other factors in this work. With cocoa, however, the study of leaf analyses has not yet reached this stage but it is proving a useful guide.

LEAF INJECTION

This is a simple technique for the rapid determination of nutrient deficiencies which has been used successfully. Evans, H. and Fennah, R. G. (1945–51).

The technique makes use of a range of weak solutions of the various plant nutrients which are injected directly into the leaf tissues. Deficiencies are indicated by changes on the colour of the leaf at the site of the injection.

POT TRIALS

These are most useful for a preliminary investigation of soil deficiencies and are relatively inexpensive. Pots are prepared, using soil from the area to be tested; a range of fertilizers is added to the pots and cocoa seeds are planted. By observing and measuring the growth of the potted plants indications regarding the fertilizers to be used in field trials are obtained. Since pot trials are easy to handle, and produce results comparatively quickly, they are useful for testing a wider range of fertilizers than would be possible in the field owing to the expense and large areas involved.

FERTILIZER RECOMMENDATIONS

Any fertilizer recommendations for cocoa soils in Fiji can only be tentative since experiments on the manuring of cocoa are still in the early stages.

One important factor contributing to the establishment and maintenance of soil fertility and physical condition of the soil is the use of organic material. Of this there can be no doubt and no excuse is offered for again stressing this all-important subject.

To summarize, organic matter is valuable for the following reasons:—

(*a*) It is a source of plant foods, particularly nitrogen.
(*b*) It improves the soil, both physically and chemically.
(*c*) It prevents the loss of soil moisture.
(*d*) It encourages the development of beneficial soil organisms.
(*e*) As a mulch, it retards weed growth and acts as a protective layer over the surface feeding roots, both against exposure to the sun and damage by weeding implements.

With all these valuable effects, organic matter is a commodity available to every farmer.

Every effort should be made to maintain a layer of decomposing organic material in a circle around the cocoa tree. The circle should extend at least a foot beyond the perimeter of the leaves.

There is a very wide range of available organic matter in Fiji; this includes farmyard manure, grass, leafmould, chopped banana stems, coconut husks, sawdust, compost, prunings from shade trees, and rice straw. In other words, it is sound practice to keep every scrap of vegetable or animal excreta from the garden or animal sheds and ensure that it is put around the cocoa.

When weeds are removed from around a cocoa tree they should be spread over the cleared ground. Care should also be exercised when a cane knife is used for weeding, as the soil is sometimes shaved of its organic layer near the base of the tree. It is therefore advisable to remove weeds by hand within a radius of two or three feet of the trunk so as to prevent injury to the roots of the tree.

The next consideration must be the use of artificial fertilizers as an aid to building up and maintaining soil fertility. Pending the outcome of the various fertilizer trials, some of which have been laid down, the following fertilizer mixture is tentatively recommended for cocoa:—

8 parts by weight of Blood-and-bone manure
4 parts by weight of Urea
4 parts by weight of Superphosphate
4 parts by weight of Sulphate of Potash.

Apply 1 lb. of this mixture to each tree over three years old every four months. Younger trees require smaller applications, depending on the age of the tree, the rate being $\frac{1}{4}$ lb. per application for new seedlings and increasing until the tree receives the full pound when it is three years old.

Where possible, mix the fertilizer with farmyard manure or rotted organic material and apply as a fortified mulch.

The annual cost of the fertilizer for one acre of cocoa, spaced at 12 ft. x 12 ft., equivalent to 300 trees per acre, would be in the neighbourhood of £15.

Growers interested in fertilizing cocoa are advised to try the above-mentioned fertilizer on a limited experimental area and take careful note of any response. Remember, it is false economy to try and save money by under-fertilizing. In overseas cocoa trials, it has been found that a limited fertilizer application often produces no results; doubling the application resulted in marked increases in yield.

An interesting example is the experience reported from New Guinea (1959) with coffee, a crop which grows best under fertility and soil conditions similar to those suited to cocoa. New Guinea coffee planters at first thought that they could manage without fertilizers. However, following expert advice based on experience in Hawaii, they found it profitable to fertilize to the extent of one pound of mixed fertilizer per tree per month, even though the landed cost of the fertilizer was almost £100 per ton. A similar mixture in Fiji would cost under £50 per ton.

SUMMARY

An attempt has been made to outline the conditions relating to soil fertility for cocoa growing. Special attention has been paid to the role of organic matter in the soil.

Notes have been given on the various plant nutrients, followed by a brief outline of experimental methods for detecting possible deficiencies in the cocoa tree and in the soil.

Finally, tentative fertilizer recommendations have been made.

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Plate 16. Establishing clonal nursery, Naduruloulou : Gliricidia maculata planted for overhead shade Photo—P.R.O

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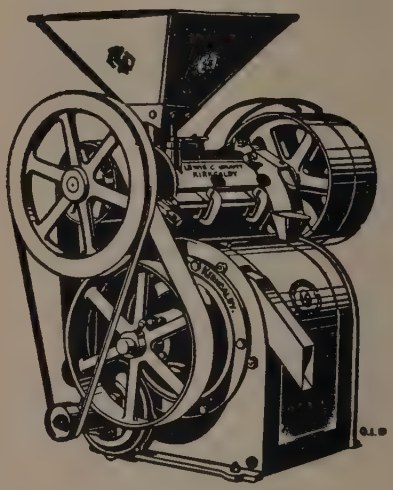

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PLANS FOR THE FUTURE

By L. W. HARWOOD

It has long been felt that cocoa would be a crop suitable for Fiji conditions. There appears little doubt that soil and climatic conditions are suitable for its growth and that cocoa will grow and yield well in Fiji.

Photo—P.R.O.

Plate 17. Examining cocoa pods prior to selection

A critical stage in the industry has now been reached. Interest, especially by Fijians, is still keen and sustained and there are signs of possible large-scale developments by estates and companies. Cocoa prices, although somewhat below the peak prices reached in recent years, are still attractive and ensure a good nett return to the producer. What is being done to prepare for this possible accelerated development ?

COCOA STATIONS

The former Plant Introduction and Quarantine Station is being rapidly developed as a Station where the main emphasis will be on the production of rooted cuttings from high yielding local and introduced clones. A nursery of clonal material has been established and is being rapidly enlarged. Propagation facilities, capable of producing a maximum of 1,000 rooted cuttings, are in operation and the installation of a Bahnson Humidifier, which will greatly increase the output of rooted cuttings, is being effected.

A similar Station, which will allow of considerably more agronomic and investigational work, is in course of development at Nagigi in the Nasavusavu area of Vanua Levu. Clonal nurseries and propagation facilities similar to those at Naduruloulou will be established.

Photo—P.R.O.

Plate 18. A good flush ; rooted cutting, Naduruloulou

The establishment of a Cocoa Station on the windward side of Vanua Levu, where large tracts of land await development, should give a tremendous fillip to the industry. Improved communications will bring the Station within easy reach of areas which were formerly most inaccessible.

QUALITY INVESTIGATIONS

Market enquiries have revealed that, whilst our cocoa is generally acceptable, it is somewhat lacking in strength of chocolate flavour.

Single-pod and small scale fermentations and local tasting panels are necessary for the proper evaluation of high yielding types located in field surveys, and should continue. These quality assessments are essential before any trees may be selected for clones or inclusion in the breeding programme.

SELECTIONS

The search for high-yielding types with the requisite strength of chocolate flavour must continue. Routine surveys and pod counts will be required for the location of promising types.

These will be subjected to a quality test and, if proved satisfactory, will be vegetatively propagated, multiplied and tested on Departmental Stations.

Hand pollinations and compatibility tests to select suitable parents for incorporation in the breeding programme will be a routine task on Stations and in the field.

BREEDING

A breeding programme designed to improve the strength of chocolate flavour in Fiji cocoa has been commenced. The distribution of rooted cuttings, which are difficult and expensive to raise, is not an economic proposition so it is hoped to obtain the required strength of chocolate flavour from the produce of trees raised from "clonal seed". This seed will be produced by crossing high-yielding local and introduced clones characterized by good bean size with other clones having strength of chocolate flavour. A number of clonal seed gardens are in course of establishment and more will be required as cocoa planting spreads to the outlying islands.

INTRODUCTIONS

West African Amelonado cocoa which is esteemed for its strength of chocolate flavour, has been successfully introduced from Malaya and established on an isolation block at Waimaro, Tailevu. Seed of this will be issued to farmers as sufficient becomes available for distribution.

FERTILIZER INVESTIGATIONS

A programme of experiments, involving both field and greenhouse work, is well in hand.

The object of these trials, which will be carried out on Departmental Stations and farmers' plots, is to ascertain the need for artificial fertilizers and the mixtures most suitable for the various soil types. Each trial is being laid down on a representative soil derived from each major type of parent mate ial.

The fertilizers being investigated are Urea, Superphosphate, Potassium salts and Lime. Work on trace elements is also being carried out in the greenhouse. In addition, investigations on the use of mulches, with and without the incorporation of artificial fertilizers, are well advanced.

This programme of fertilizer investigations will take several years to complete but it will enable the Department of Agriculture to make specific recommendations for the various soil types on which cocoa is grown. The results should be of particular value for those soils which are found in suitable climatic zones and have satisfactory physical properties but whose nutrient status is known to be low.

FERMENTATION STUDIES

Work has commenced on a comprehensive series of investigations which will be carried out on Departmental Cocoa Stations, in the laboratory and in the field. The aims of these investigations are—

(1) to carry out a series of laboratory tests which will provide the necessary basic information for fermentations on a field scale;

(2) to standardize a method of fermenting and drying cocoa in the field which will produce a grade of cocoa beans suitable to the trade;

(3) To assess the quality of cocoa produced by trees considered for inclusion in the cocoa breeding programme.

A properly equipped laboratory is being set up at the Cocoa Station, Naduruloulou, and subordinate staff has received training in the necessary techniques.

A fermentary and Samoan-type cocoa drier, which is relatively inexpensive to construct and operate, and which should be suitable for groups of farmers or co-operatives, has been installed and operated at Naduruloulou. Similar units will be established in other areas of the Colony as the cocoa comes into bearing. Departmental staff, fermentary operators and staff will receive the necessary training at these centres.

Large-scale modern processing plant suitable for use by large estates will be a feature of the new Vanua Levu Station.

MARKETING AND LEGISLATION

Overseas buyers have stressed the need for properly fermented and well dried beans of an even grade. This appears particularly necessary and desirable as Fiji's cocoa beans will have to compete in the open market with those from established cocoa territories whose marks and grades are well known to the trade.

In order that our produce may attract a ready sale and a good price, it may be desirable for the Department of Agriculture to undertake the processing and marketing of cocoa beans until such time as export standards have been set and satisfactory schemes evolved. However, the Department is not contemplating processing the beans of any organization which has sufficient capital and plant to handle its own produce.

With the development of Stations and the expansion of the industry further investigations will become necessary. These will include economic, entomological and pathological studies.

The lack of Stations in the early stages of development did not permit reliable costs of establishment to be prepared. These are obviously necessary and will be prepared in the light of experience gained as the industry progresses.

The Rose Beetle (*Adoretus versutus*), which can severely damage young cocoa plants, is obviously one insect which merits serious attention. So, too, does the fungus disease *Botryodiplodia theobromae* which, although normally a secondary fungus attacking damaged tissues, has appeared as a root rot in Fiji.

To date, cocoa planting has been restricted ot the main islands of Viti Levu, Vanua Levu and Taveuni. Planting is now being extended to the Lomaiviti group and Kadavu. Increased seed supplies should result in greatly accelerated planting.

Cocoa is a permanent crop which repays the farmer for careful preparation and maintenance. Standards of preparation and after-care, althoug improving, still fall far short of the optimum. For best results, farmers must appreciate that cocoa is an orchard crop which requires high a standard of preparation and management. The success of the industry could well depend on the care the tree receives from the farmer.

New Agricultural Publication . . .

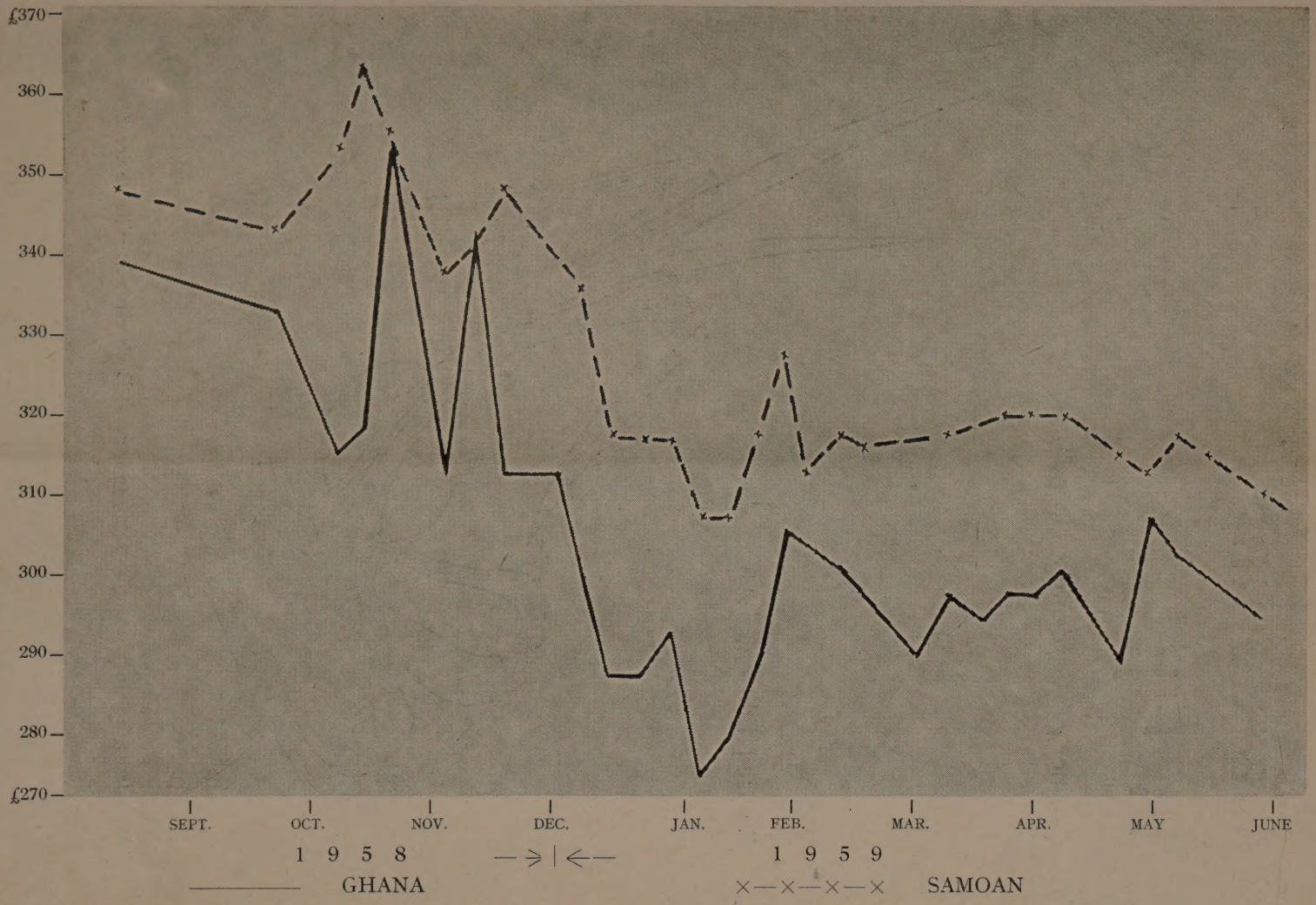
THE WEEDS OF FIJI

BY J. W. PARHAM

A bulletin describing the weeds of Fiji has been published and is on sale at the Department of Agriculture, Suva.

The bulletin contains botanical and general descriptions of most of the major and minor weeds of cultivation, pastures and waste places in the Colony, together with notes on their distribution. About 90 of the most common weeds are illustrated by line drawings.

The price of the bulletin is five shillings and orders may be addressed to the Director of Agriculture, Suva.



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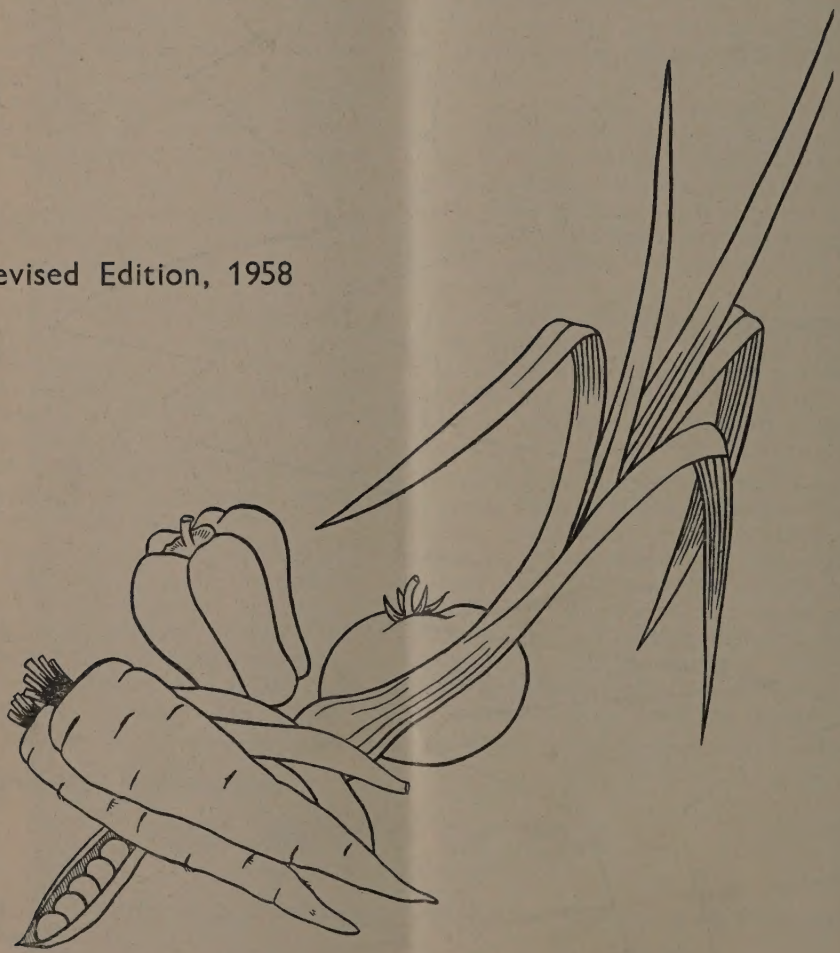
(Formerly "Gardening Notes")

Revised Edition, 1958



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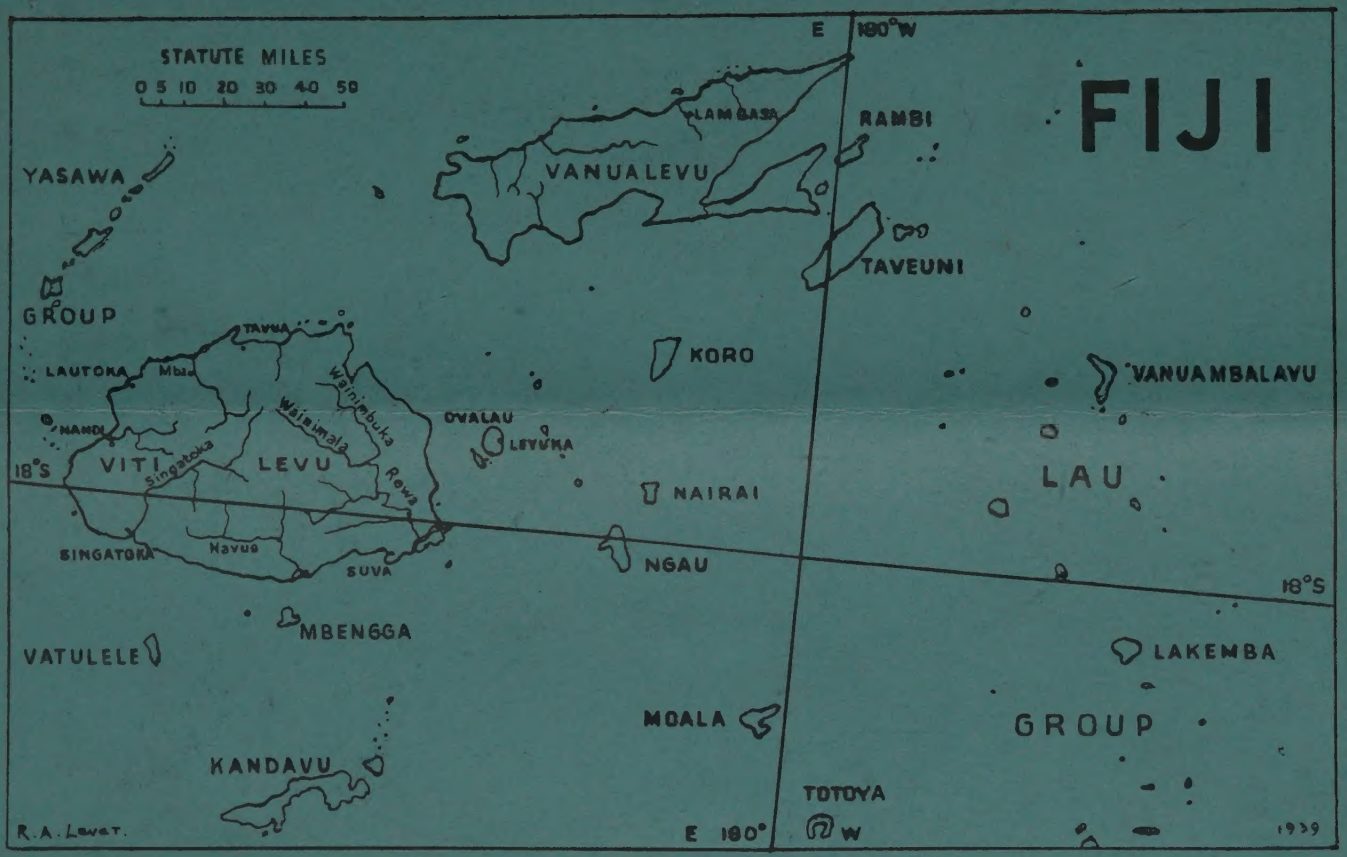

So as to include Kadavu and Totoya within the framework available the map has been rotated some 6° to the east.